

Nothing Succeeds Like Failure:
The Development of the Fireproof Building
in the United States, 1790-1911

by

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B.A., Oberlin College, 1972
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Submitted to the Department of Urban Studies and Planning
in partial fulfillment of the requirements for the degree of

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Abstract

This study is about a serious problem for the U.S. in the nineteenth century -- urban conflagration -- and how improved buildings contributed to solving it. Buildings improved in the sense that they became more fire resistant, a function of the materials used to build them as well as how the space inside was arranged and the presence of automatic fire suppression equipment. These were technological developments. In this century of great technological change, the "industrial revolution" in building construction resulted to a large extent from the effort to make buildings fireproof.


What made a building fireproof first and foremost was the materials of construction. Wood, a cheap and versatile material, was the principal one for framing the interiors of ordinary buildings. In fireproof buildings, in contrast, no wood was used constructively; all the materials were noncombustible. Consequently, fireproof buildings also were very expensive compared with alternatives and few Americans opted to build them. The largest customer for fireproof buildings in the first part of the nineteenth century was the federal government, and it did much to advance the technology.

After the great fires in the early 1870s, fire resistant construction began to receive much attention from architects, building materials manufacturers, engineers, and fire insurance underwriters. New materials were introduced and the technology of fireproof construction developed. It was in the fireproof buildings that the new materials of building construction -- iron beams, clay products, and concrete -- were introduced, because they were noncombustible. Nevertheless, fireproof construction did not become common until it was made compulsory under city building codes. At the close of the nineteenth century, many cities required that certain buildings -- i.e., tall buildings -- be fireproof. Eventually more kinds of buildings were required to be fireproof. These laws helped expand the market for fireproof construction materials.

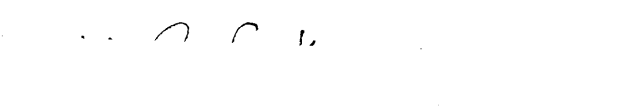
The technologies that evolved from the experiments and hard lessons learned over the course of the nineteenth century were becoming the standard ones for commercial buildings in America's downtowns in the twentieth, and helped bring to a close the era of great conflagrations. After the first decade, the attention of fire safety experts shifted away from the problem of general conflagration and toward the safety of occupants in buildings.

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Acknowledgments

For many years, I have treasured a page from an antiquarian bookseller's catalogue that listed a book by F. C. Moore titled Economical Fire-Resisting Construction. After describing the book, the dealer wrote, "when the history of fire-proof building comes to be written, F. C. Moore will have a place in it." This bookseller not only knew that there was such a thing as a fireproof building but also that the story of its development had not been told. He seemed to be suggesting that it should be.

The materials and methods of construction developed in the nineteenth century for making buildings fire-resistant became the standard systems for constructing commercial buildings. The increase in fire resistant buildings in America's downtowns helped bring to a close the era of great urban conflagrations. Yet the evolution of the technology of the fireproof building, and how it was shaped by law and economics, had never been explored as such. This is the story I tell in the pages that follow.

Fortunately, my dissertation committee agreed that the story was worth telling. For their advice and encouragement, I would like to thank my thesis advisors: Robert M. Fogelson, Merritt Roe Smith, and Peter Temin of M.I.T. A ten week fellowship at the National Museum of American History enabled me to determine that there was an interesting story in the history of the fireproof building. Support from a Society for the History of Technology/Historic American Engineering Record fellowship helped me complete my research. I am particularly grateful to Lawrance Hurst, a student of British fireproof floor systems, for sharing his knowledge and sources with me, and to Arnold Pacey, who was equally generous with his knowledge about nineteenth century buildings. Robert Thorne, editor of Construction History, encouraged me to believe that there was an audience for this topic when he published a paper I wrote, in which I compared British and American fireproof construction in the nineteenth century. Many building owners have allowed me poke around in their buildings, and many historical societies, historical commissions, and building owners have answered my questions; I am very grateful to all of them. Finally, I would like to thank my parents for their financial support and my bosses at the Massachusetts Executive Office of Communities and Development, who allowed me to keep an unusual work schedule while I was working on my doctorate.

Contents

	Page
Abbreviations	11
Chapter 1. Introduction	13
Chapter 2. The Solid Masonry Fireproof Building, 1790-1840	34
Chapter 3. Introduction of the Iron and Brick Fireproof Building in the U.S., 1840-1870	75
Chapter 4. Response to the Great Fires: Experimentation in the 1870s and Early 1880s	149
Chapter 5. Mill Fire Protection Methods Enter the Mainstream	218
Chapter 6. Triumph: the Fireproof Skyscraper, 1885-1910	285
Chapter 7. Calamity: the Need for Attention to Life Safety	345
Glossary	375
Bibliography	376

List of Abbreviations

AABN	<u>The American Architect and Building News</u>
AFM	Associated Factory Mutual companies
AIA	American Institute of Architects
ARABJ	<u>The Architectural Review and American Builders' Journal</u>
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
BMMFIC	Boston Manufacturers Mutual Fire Insurance Company, Boston, Massachusetts
EA papers	Edward Atkinson papers, Massachusetts Historical Society
HABS	Historic American Buildings Survey
HMSO	Her Majesty's Stationery Office
IA	<u>Inland Architect</u>
IEES	Insurance Engineering Experiment Station, Massachusetts Institute of Technology
JRF papers	John Ripley Freeman papers, Massachusetts Institute of Technology
JFI	<u>Journal of the Franklin Institute</u>
LC	Library of Congress
MHS	Massachusetts Historical Society
MMFIC	Manufacturers Mutual Fire Insurance Company, Providence, Rhode Island
NBFU	National Board of Fire Underwriters
RG 121	Record Group 121, Records of the Public Building Service, National Archives, Washington, DC
RIBA	Royal Institute of British Architects
RIHS	Rhode Island Historical Society
RM	Robert Mills papers microfilm
T.U.W.	Thomas U. Walter collection, Philadelphia Athenaeum

Chapter 1.

Introduction

This study is about a serious problem for the United States in the nineteenth century -- urban conflagration -- and how improved buildings contributed in large measure to solving it. Buildings improved in the sense that they became more fire resistant, a function of the materials used to build them as well as how the space on the interior was arranged and the availability of automatic fire suppression equipment. These improvements were technological. The nineteenth century was a time of tremendous technological change, and the "industrial revolution" in building construction resulted to a large extent from the effort to make buildings fireproof. Government played an important role the development of this technology.

The Conflagration Problem and Its Resolution

From the earliest days of European settlement, American towns were plagued by conflagration. The destructive potential of fires only increased over time as population and economic activity grew and became concentrated in cities. Several of the world's worst fires in the nineteenth and early twentieth centuries occurred in the U.S.: New York in 1835, Chicago in 1871, and San Francisco in 1906. But these were only the most catastrophic of many conflagrations. Cities all over North America burned at one time or another: Portland, Maine and Jacksonville, Florida; Charleston, South Carolina and Spokane, Washington. Hardly a year passed in the last century without a serious fire somewhere. One authority counts 176 urban conflagrations (defined simply as a fire that involves groups of buildings and destroys large amounts of property) during the period 1800 to 1909, not including the fires immediately before and during the Civil War.¹

These fires were not merely a function of the times, since cities in Great Britain and western Europe suffered far fewer serious fires. Conflagrations were rare in western Europe even though compared with American cities, major European cities were as densely built-up,

¹ Joseph K. Freitag, Fire Prevention and Fire Protection, As Applied to Building Construction (New York: John Wiley & Sons, 1921), p. 6.

or more so, and had inferior provisions for fire fighting. The per capita fire loss in six western European countries at the turn of the twentieth century was perhaps one-tenth the U.S. amount.² By one estimate, about half of all recorded conflagrations between 1815 and 1915 occurred in the U.S. and Canada, and most of these were in the U.S.³

This pattern reversed, quite dramatically, after the opening years of the twentieth century. No trend pointed to this turnaround: the number and destructiveness of conflagrations were as bad at the end of the nineteenth century as at the beginning. In fact, two of the nation's worst conflagrations, Baltimore in 1904 and San Francisco in 1906, occurred in the first decade of the twentieth century. However, these were the last great fires in the U.S. Since then, conflagrations have struck some older cities, most recently the small city of Chelsea, Massachusetts, in 1973; and forest fires have destroyed homes in ex-urban areas, for example in California in this decade. Property continues to be lost to fire and many Americans die and are injured in fires each year, but the likelihood of conflagration in an American downtown today is very remote. As the authoritative Fire Protection Handbook assesses the relative risk,

Five of the ten costliest fires of all time were fires that engulfed whole cities, while only one of the ten costliest fires of the 1980s could even be called a group fire. The risk of conflagration has declined significantly from the pattern of a century ago.⁴

This result was brought about by a number of developments. Among the factors that contributed were better municipal water supply; improved fire fighting equipment; creation of salaried fire fighting organizations under municipal control; widening of old streets and building wider streets in new areas; and increased space between buildings, which serve as fire breaks.

Equally important -- some would argue, the most important factor -- has been the

² Joseph K. Freitag, Fire Prevention and Fire Protection, pp. 11-12.

³ John Weaver and Peter De Lottinville, "The Conflagration and the City: Disaster and Progress in British North America During the Nineteenth Century," Histoire sociale-Social History vol. 13 (Nov., 1980), p. 417.

⁴ John Hall, Jr. and Arthur Cote, "America's Fire Problem and Fire Protection," in Arthur Cote, editor, Fire Protection Handbook 17th edition (Quincy, Mass.: National Fire Protection Association, 1991), p. 1-10.

increased fire resistance of buildings.⁵ This greater fire resistance was the result of improvements in the technology of building construction: the materials, planning, and equipping of buildings developed for the purpose of protecting them from fire. The technology evolved over the course of the nineteenth century. As old buildings were torn down and replaced with new, fire resistant ones, and as existing buildings were retro-fitted with automatic fire suppression appliances, the danger of conflagration subsided.

While improved buildings were an important factor in this turnaround, the story of how the technology developed and spread is not an illustration of the maxim of the better mousetrap. The fact is, Americans were reluctant to build fire resistant buildings. To understand why, consider the mousetrap for a moment: how many people would buy the "better" version if it cost twice as much as the old one, when the old one performs well enough for the owner's purposes? Probably not many. And this is analogous to the situation of technologies designed to make buildings fire resisting. With a few exceptions, Americans did not voluntarily adopt the new materials that would make their buildings safer, for the simple reason that they cost more than ordinary ones. Fire resisting buildings became widespread only when property owners were compelled by local building law to adopt them. Thus, the history of the development of the technology of the fire resisting building is a story of the interaction of technology, economics, and politics in the cause of solving the conflagration problem.

The Economics and Politics of Safe Buildings

Despite the dismal record of the last century, American communities had long tried to avert conflagration with laws intended to eliminate the causes of fire (*fire prevention*) and to check the spread of fires once started (*fire protection*).⁶ This was done through building

⁵ The question, what factor contributed most to reducing the number of conflagrations in the last century, has been the subject of one modern study. It concluded that improvements in building construction, along with increases in average house lot size, were the most significant factors. (L. E. Frost and E. L. Jones, "The fire gap and the greater durability of nineteenth century cities," Planning Perspectives vol. 4 (Sept., 1989), pp. 333-347.) This conclusion rests on the observation that firefighting is ineffective in a conflagration and therefore could not have been as consequential as other factors. In my study, I make no attempt to apportion credit among the various factors. I simply claim that improved building construction was an important factor.

⁶ Italicized construction terms in the text (except those in quotations) are defined in the glossary.

laws, which are exercises of police power and as such are very ancient. America's building laws are designed to be preventative rather than punitive. They state what should be done in order to prevent unwanted events and impose penalties (usually with fines) for non-compliance, rather than leave matters to the owner and then punish them after something goes wrong.

Within the fire protection category, there are three safety issues: the spread of fire from one building to the next, the spread of fire within a building, and danger to life. For most of the nation's history, building regulations dealt with the first of these three issues, the spread of fire between building. The common approach was to regulate how buildings were to be constructed. In most municipalities for most of the nineteenth century, the laws were very simple. Typically, they defined a zone, often called the "fire limits," within which the exteriors of all buildings could only be constructed with noncombustible materials. The laws might also specify minimum dimensions for walls and spacing between buildings. The intent of the rule against building with combustible materials was to reduce the amount of potential fuel for the fire. The provisions regarding the thickness of walls were intended to assure that walls would be sturdy enough to contain a fire and be effective barriers to its progress. A fire confined to the place where it starts could be extinguished more readily. Once it spreads beyond its starting place and ignites adjacent buildings, it could become a conflagration.

But if the threat of conflagration was so great and these measures -- building with noncombustible materials, making walls thick enough to stand even if the interior of a building was gutted -- helped prevent them, why was it necessary to compel people to build this way? Why did not everyone build more substantially, voluntarily?

First, considering the public's perception of risk, while the last century in retrospect seems like a dangerous time, very likely most people worried little about fire. Safety is never high on the public's agenda. The modern attitude toward building regulation, "rampant indifference punctuated -- in the wake of a building catastrophe -- by occasional outrage," was probably the same in the nineteenth century.⁷ Moreover, it was not irrational for most

⁷ Francis Ventre, Social Control of Technological Innovation; the Regulation of Building Construction, PhD dissertation, M.I.T., 1973.

owners to bet that their buildings would not burn. Some types of buildings, such as theaters, hotels, and cotton mills, burned regularly; but fires in other types of buildings were not inevitable, and owners could reasonably expect to avoid them.

Still, owners might have constructed their buildings more securely if the cost of doing so was the same or nearly the same as that of ordinary construction. Unfortunately, the cost difference between fire resisting and ordinary construction was substantial. Even arguments that fire-resisting buildings had advantages beyond safety -- for example, they were more permanent than ordinary buildings -- did not impress cost-conscious owners. Every safeguard increased the cost of construction without compensating the owner sufficiently for the extra cost, or else people would have built them. The fact is, the community, not the owner, was the beneficiary of the extra investment.

To understand why this was so, imagine a building in a village in close proximity to other buildings. The building is made entirely of wood -- wooden walls, wooden frame -- and it catches fire. The fire is likely to consume the whole building and, unless quickly extinguished, spread to nearby buildings. Now imagine a building with brick walls and a tile roof. A fire on the inside of this building might be contained, which would allow the fire fighters more time to extinguish it. Who gains in the second case? Not necessarily the building owner, who may still lose everything inside the building to fire and water. He is better off only to the extent that he has four walls and the consolation of his grateful neighbors, who are glad the fire did not spread to their buildings. The neighbors are spared, but at the owner's expense.

Building laws were designed to do this. They did not protect the owner and his property, necessarily, but protected the community from owners whose actions could endanger it. The dangerous actions the laws forbade were owners' inclinations to build cheap buildings. Cheap buildings, like old mousetraps, were perfectly adequate as buildings. They were only inferior to fire resisting buildings in one respect, which was safety. This is why better building construction had to be mandated by law. When the economic benefit of an investment goes to someone other than the investor, he will under-invest. Economists would call the impact of the owners' decisions to build flimsy buildings a negative externality. Thus, to protect the community from the possibly devastating consequences of the money-

saving decisions of some building owners, laws were passed that required owners to spend more than they wished.

Nevertheless, fire laws could only be as strict the local citizenry would accept. In most cities, for most of the nineteenth century, the laws advanced little over those in colonial times. Some cities, notably Boston and New York, had comparatively detailed laws by the 1870s. However, as long as the laws prescribed little more than the materials for constructing the exterior of buildings, the nation's downtowns -- the usual extent of the fire limits -- were vulnerable to conflagration. For this reason, the rules concerning the materials of construction were prospective and therefore would be effective in the long term, as the old non-complying buildings were replaced with new ones. But even if every building in the fire limits had been "brick" or "stone," there still would have been plenty of kindling on the inside, since floors, partitions, staircases, wall and ceiling lath, roof frames, and window frames customarily were made of wood. The heat alone of a serious fire could ignite the window frames, wood cornices, and roof boards of nearby buildings and spread inside them. Often the walls of burning buildings collapsed and flames would engulf neighboring buildings.

The Private Solution to the Fire Problem: Origins of Fireproof Buildings

Owners who could not wait for the salutary effect of the laws to be realized, or who built in cities that did not have fire laws, had another option: to construct their buildings more fire resistant than the law required. These buildings were intended to deal with the second fire safety issue, checking the spread of fire internally, as well as the first. The decision to build this way was based on several factors:

1. the wealth of the owner
2. the owner's assessment of risk
3. whether the owner could insure against loss

With respect to the first factor, obviously a person had to have the resources to build a more expensive building before he could do so. Secondly, only owners who judged that they might suffer a fire would be likely to bother spending the extra money. The matter of insurance has two aspects: first, the cost of insurance and second, whether it could cover all that might be destroyed in a fire. If an owner could save enough in insurance payments, say, enough to pay interest on the cost on the additional cost of building more securely, he might

be inclined to make the investment. However, even though the price of insurance in the last century was at times very high, the difference in premium rates for good and bad buildings was never great enough to cover the cost of making a building truly fire resisting.

There were two reasons for this: the crude methods of insurance rate setting, and the large gap between the cost of fireproof and ordinary construction. Insurance rates, for most of the century, were set for broad categories, taking into account construction and occupancy (the use of a building) only. Rarely were distinctions made within categories: a fire-resistant cotton factory was charged the same rate as a cotton factory that was not. Only at the end of the century did the industry begin to compile loss statistics for all companies and develop a rating system that made finer distinctions, and enabled underwriters to reward better buildings and penalize inferior ones.

Working against the cause of better construction was the fact that fireproof construction was more costly than ordinary construction. Even while cost difference between fireproof and ordinary buildings -- assuming a building could be constructed either way -- narrowed over the course of the century, it never disappeared. Refinements in rate setting, and fluctuating rates, still were unlikely to result in savings sufficient to induce an owner to build fireproof. How this works might best be shown with an example. Assume the construction cost difference was 20 percent. A building might cost \$200,000 if fireproof and \$160,000 if not. Assume insurance rates on the buildings are 2%/\$100 for the ordinary building and half this rate, or 1%, for the fireproof building, and 80% of the value of the buildings are insured. The annual premium for the fireproof building would be \$1,600, and for the ordinary building, \$2,560. Thus, the fireproof building cost \$40,000 more to build and saves \$960 per year in insurance premiums. If the owner also occupied the building, he could save considerably more, in reduced premiums on the contents of the building (usually more valuable than the building), making the insurance savings more of an inducement. Insurance savings, under the schedules developed at the end of the century, made some items of safety equipment cost effective, for example, automatic sprinklers and alarms, standpipes, metal window shutters, or wire glass for windows. But it is doubtful that insurance savings alone could persuade someone to build fireproof.

Special circumstances encouraged fireproof construction, however. An owner might

have certain kinds of property, such as important records, works of art, or valuable machines that he could not replace easily or at all, or the building might house sick or incarcerated people who could not easily escape in a fire. In these cases, an owner might wish to build fireproof, regardless of the consequences for insurance costs.

Owners who wanted absolute security, who also had money to pay for it and believed they were at some risk, who were most inclined to build fire resisting buildings voluntarily. These better buildings had positive externalities, in that they also protected adjacent structures. However, the owners made the extra investment entirely for the sake of protecting the contents of their buildings, from fires originating either outside or inside the building. Owners in this category were the natural clients for "fireproof" buildings.⁸

The Introduction of Fireproof Construction

Beginning in the late eighteenth century, buildings called "fireproof" began to be built in the U.S. These buildings were unlike the ordinary brick and slate roof buildings required by fire laws: in the fireproof buildings, the interior structure as well as the walls and roof covering were made of noncombustible materials. In modern terms: a fireproof building should confine a fire on the inside to the room or floor where it starts; remain structurally sound even if the contents of the building are consumed; and protect the building from fires originating outside it. This is what all fireproof buildings were intended to accomplish. To this list was added, at the end of the nineteenth century, the further condition that cost of repairing a fireproof building after a fire should be minimal. In other words, a fireproof building should not only withstand a blaze, but withstand it as far as possible uninjured.

These objectives were accomplished through the way space inside the building was arranged -- isolating horizontal floors from vertical shafts -- and, eventually, through automatic fire suppression equipment, but principally through the materials of construction. In a fireproof building, all the materials that carried loads and were subject to strains were

⁸ The term "fireproof," applied to buildings, was still used in the 1940s at least, although already in the nineteenth century many experts began to prefer the term "fire resistant," which more accurately described the buildings and was less confusing to the public. In this study, the term "fireproof building" is used to mean a building in which no wood was used constructively. All fireproof buildings are fire resistant, and buildings that are not fireproof may also be fire resistant. The word "fireproof" is not hyphenated in the text; it is hyphenated in quotations and titles, if it was written that way in the original.

noncombustible. In an ordinary brick building, the noncombustible walls created vertical barriers. Fireproof buildings had, in addition to noncombustible walls, noncombustible floors and roofs, which created horizontal barriers to the upward progress of a fire.

Regardless of the materials and methods used to build them -- and, of course, these changed over the course of the nineteenth century -- all fireproof buildings had at least one thing in common: little or no wood was used constructively. Wood might be used for non-structural purposes, for example, in finishes, doors, windows, and floor coverings, although even these elements were made of noncombustible materials in the most thoroughly fireproof buildings. Otherwise, the posts, beams, and floors were made of noncombustible materials. The only exception to this rule was a system of building, popular in the 1870s and 1880s, in which wood floors were protected with a layer of noncombustible material. But these buildings were more commonly called "semi-fireproof" and most experts did not consider them fireproof. Another kind of fire resistant system in the nineteenth century was "slow-burning construction," in which wood was used structurally; this is why buildings constructed with this system were called "slow-burning" rather than "fireproof."

Fireproof construction technologies -- materials and practices -- succeeded one another and, conveniently for the historian, the technological regimes divide into a neat chronology. In any period, the self-styled experts on fireproof construction -- the architects, building materials manufacturers, builders, fire insurance underwriters, and engineers who designed and wrote about fireproof buildings -- generally agreed on what constituted the best fireproof construction practice. Thus, at the end of the century, no authority on fireproof construction considered a vaulted building -- the first style of fireproof construction -- to be fireproof, even though the historically-minded ones recalled that this kind of building was once considered fireproof. These technological regimes are the basis for the periodization, and chapters, of this study.

It is possible to follow the evolution of fireproof building construction because a fireproof building, in the nineteenth century, was a kind of building. The method of construction was independent of the use of the building. Moreover, as suggested above, there was much consensus at any point in time as to what constituted fireproof construction so it is trivial to distinguish fireproof buildings from ordinary ones.

The First Period of Fireproof Construction: Government Patronage

The first style of fireproof construction in the U.S. was the solid masonry, or vaulted, system. This system -- the subject of Chapter 2 -- was used from roughly 1790 until 1840. In these buildings, the floors are made of masonry arches that spring between massive walls or thick, masonry columns called piers. Not only were such buildings considerably more expensive, they also took much longer to build, and arguably -- with their heavy, damp walls -- were inferior to ordinary buildings as buildings. The vault buildings were rare even in their day but a few examples remain: the east wing of the Treasury Department in Washington, D.C. is a well-preserved one.

In this period, the clientele for fireproof construction included principally government bodies at all levels, but the federal government in particular. Private owners that opted for such buildings included banks and institutions. Again, these owners shared a desire for complete security for the contents of their buildings. Among the government buildings were prisons and hospitals, built fireproof for the sake of protecting the people inside.

A much more practical system of fireproof construction came into use in the 1840s: the iron and brick arch system. In this system -- adapted from methods developed in England -- iron columns replaced masonry piers and iron beams replaced heavy interior walls. The floors continued to be made of brick arches, for the most part, but the arches were shallower than the barrel arches common in vault buildings, so they took up less head room. This was the predominant system of fireproof construction in the 1850s through the 1860s and is the topic of Chapter 3.

An important feature of these buildings was structural iron, with which American architects and builders had had very little previous experience. Americans relied on British authorities for guidance in designing the interior iron frames of these buildings, but they also began to conduct their own research. Most of this was conducted under the auspices of the federal government, the largest customer of fireproof buildings. The government's fireproof building program in the 1850s was in the hands of a technically minded architect and an engineer who sought to encourage private owners to adopt this system of construction. In seeking Congressional appropriations to test iron for government buildings, they argued that the results also would be valuable for private interests, who did not have the resources to test

for themselves.

Through the tests it sponsored, through the large purchase of structural iron, and by the example of its buildings, the federal government played a key role in the development of this technology. Its role in this case was analogous to the one it played in the development of interchangeable parts technology. In the latter case, machine tools that could turn uniform parts, any one of which could be used in assembling a final product, were developed in U.S. government armories for manufacturing muskets and rifles for the military.⁹ Unlike military weapons, firearms intended for the private market did not have to be repaired in the field and so did not have to meet the government's high standard of perfect interchangeability. Consequently, private arms makers were under no pressure to undertake the lengthy and expensive work of developing machine tools for this purpose. Once the technology for making uniform parts was developed for the government, however, it spread to private manufacturers and had tremendous consequences for manufacturing processes and productivity. Nevertheless, it was originally developed to meet special, essentially non-economic requirements. Likewise the government's special requirements for buildings -- for absolute security from fire -- caused it to adopt, and accordingly help develop, a technology that in its formative period was too costly for the private sector.

The iron and brick arch system was adopted by a wider range of private owners: insurance companies and publishers, in addition to local government, banks, libraries, and schools.

The Second Period of Fireproof Construction: Protection of Tall Buildings

The great fires of the early 1870s, in Chicago and Boston, came at a propitious time for the advance of fireproof construction technology. They inspired a number of building professionals to make structural fire protection a special field of study. These experts were especially interested the effect of fire on fireproof buildings.

Coincident with the rise of the fire expert were national organizations of professionals involved in building -- associations of architects and engineers -- and the founding of

⁹ Merritt Roe Smith, Harpers Ferry Armory and the New Technology (Ithaca: Cornell University Press, 1977).

professional periodicals with national circulations, which could disseminate the findings of the experts. The technology for manufacturing iron had progressed considerably. Despite a depression that lasted most of the 1870s, the nation's wealth was growing. Its cities were growing as well. Thus, the number of potential clients for fireproof buildings was increasing along with institutions for disseminating information on fireproof construction. Although the poor economy of the decade stalled building construction, innovation was strong, spurred by the great fires. Chapter 4 discusses the products patented in this decade, which came into wide use when the economy recovered at the end of the decade. Notable among these were hollow tile floor arches, hollow tiles for making roofs, and tile fireproofing for iron columns.

Another important development in this decade was the growing tendency to build tall buildings. In the 1870s, following the introduction of passenger elevators, the first 10-story buildings appeared. By the early 1880s, tall buildings had begun to sprout in cities around the country. The tallest buildings were fireproof or semi-fireproof. However, they were built this way at the owner's option, since no city required that any building be fireproof. But as the number of tall buildings increased, so did concern about their safety. Quite simply, a fire in the upper stories of a tall building could not be fought from the ground. Hose streams, even in cities with good water pressure, were only effective up to the fifth or sixth floor. Fire underwriters and others concerned about the safety of the tall buildings advocated that laws either limit building heights or require that tall buildings be fireproof. The latter course was adopted in the cities that had comprehensive fire laws and, not coincidentally, also had tall buildings. Thus, in the mid-1880s, for the first time, some buildings were required by law to be fireproof.

Besides the legal requirement to make them fireproof, very tall buildings, as a practical matter, had to be constructed with metal frames and noncombustible walls. There was no structural obstacle to having wood-framed floors in a skyscraper, although no one seems to have tried to build this way. Still, the fact that owners were inclined to use noncombustible materials to construct their buildings does not mean that laws requiring them to be fireproof were unnecessary. The materials of construction were only part of what made a building fireproof. The codes were necessary to prevent owners and others involved with a building from skimping on safeguards -- e.g., neglecting to put sturdy fireproofing around

columns, something that would not affect the stability of the building but would affect its security in a fire.

The requirement that tall buildings be fireproof was a watershed for fireproof construction, as discussed in Chapter 6. As the number of tall buildings increased, the market for fireproof building products expanded, new manufacturers entered the business, and new products were introduced. New products developed for fireproof buildings included new styles of tile floor arches, structural steel, and concrete. Concrete was used both for floors in metal-framed buildings and for making frames, in place of metal.

The skyscraper can be defined in several ways: by height or according to the structural system used.¹⁰ From a structural standpoint, the innovation that permitted really high buildings to be built was the skeleton frame. Where the floors and roof of a traditional, load-bearing wall building are carried by the walls, in a skeleton frame building, the floors, roof, and even walls are carried on a metal framework. Even contemporaries considered the skeleton frame the most revolutionary development in building construction technology in the nineteenth century. The skeleton frame not only was key to the unprecedented heights of buildings, but also reduced construction time considerably. In skeleton frame buildings work on all floors could proceed simultaneously once the frame was erected, rather than one floor at a time as in bearing-wall buildings. The skeleton frame heralded an era of speed in the building industry as much as height.

As consequential as the skeleton frame was for building tall, it was not invented as a solution to the problem of how to build tall. Rather, it was a very natural continuation -- amplification, as one contemporary put it -- of the development of fireproof construction, employing materials that had been introduced in buildings that were fireproof and not necessarily tall. Greater height, like great speed, were happy by-products of the system.

In other words, the desire to build tall did not call the means for doing so into being, as many modern historians would have it. For example, Carl Condit, in his classic work on

¹⁰ The first "skyscrapers" were given this name because they were very tall compared with other buildings. The word could also be defined to include only skeleton frame buildings, which is how Tom Peters defines it. ("The Rise of the Skyscraper from the Ashes of Chicago," Invention and Technology vol. 3 (Fall, 1987), pp. 14-23.)

the history of American building practice, argues that economic conditions -- rising land values and demand for office space -- drove innovation in building construction technology, c. 1865-1900, since these conditions forced buildings to be built higher.¹¹ This explanation does not account for the fact that the materials of the tall building preceded the appearance of the tall building. Nothing new had to be created to construct the pioneer skeleton frame buildings.

Market forces did not bring these materials into being; the incentive was non-commercial: a concern for safety. The owners who chose to build fireproof despite the higher cost of doing so called into being the materials that made skyscrapers possible. In fact, it might be argued that the high cost of fireproof construction itself forced buildings to be tall, rather than, for example, the cost of land or demand for office space. As one contemporary wrote, "all high buildings are necessarily fireproof; and conversely ... to be most profitable are necessarily high."¹² By the mid-1880s, codes in a number of cities required tall buildings to be fireproof. Of course, no law could make owners build tall, and certainly tall buildings would not have been built if there truly were no tenants or buyers. But by requiring that eight or nine story buildings be fireproof, the laws may have encouraged owners to build taller than they might have if they could have used wood inside. From this perspective, it is unnecessary to say why an owner wanted to build tall -- whether because he expected an immediate profit or for status. The point is that the means to build tall existed independently of, and before, the desire to do so. And what brought these means into existence was not economic forces.

Another riddle this interpretation solves is the tenuous connection between the iconographic "engineered" buildings of the nineteenth century -- the Crystal Palace, Eiffel Tower, and train sheds -- and the skeleton frame skyscraper. The engineered buildings were identified by the influential historians of Modern architecture, Sigfried Giedion and Nikolaus Pevsner, as the ancestors of the skyscraper, which eventually led to Modernism -- a style that celebrated engineering. But as the structural historian Robert Thorne writes, "the most

¹¹ Carl Condit, American Building (Chicago: U. of Chicago Press, 1982) 2nd ed., pp. 80-81 and 114-117.

¹² Peter B. Wight, IA vol. 19 (March, 1892), p. 21.

awkward aspect of that interpretation ... was its failure to account for the hiatus between the completion of the most celebrated works in iron and the development of their modern successors."¹³ In fact, there was no direct connection. The tall building did not evolve from buildings that looked superficially like skyscrapers, but from fireproof buildings, in which the technological innovations are hidden from view. There was no hiatus in the course of development of fireproof construction. Development occurred behind the walls, in the structural metal, hollow tile, and concrete; few of the fireproof buildings looked technologically innovative from the outside.

In the case of building technology, the search for safety led to innovation. The economic effects of this process were not only that property was protected from fire: the effort to create a better, fire resistant building itself led to technological advances. The materials and construction methods that transformed American building originated in the course of development of fireproof construction. As the architectural writer and educator Thomas M. Clark explained in 1884, "The most important changes in regard to habits of construction that have been introduced within the last twenty years relate to protection from fire."¹⁴

In every period, fireproof buildings were the most common kind of high-tech building. High-tech is defined here as a kind of building that was so different from traditional ones -- either because of how it was built or the materials of construction -- that the old rules of thumb were of little use. Rather, the designers had to use a scientific approach, conducting or seeking the results of tests of materials, applying mathematical formulas, and so on. Rare as they were, fireproof buildings still were much more common than other examples of high-tech buildings in the last century. For example, the engineering of long span roofs for train sheds, another high-tech sort of building, had little application to ordinary buildings, which did not need such roofs. In fact, when iron roofs began to be built, they were for fireproof buildings. Thus, it was in the context of fireproof buildings that architects gained experience

¹³ Robert Thorne, "Introduction," The Iron Revolution, Essays to Accompany an Exhibition at the RIBA Heinz Gallery, June-July, 1990, p. 8.

¹⁴ T. M. Clark, "Recent Improvements in Building," AABN vol. 16 (Nov. 15, 1884), p. 231.

using, and solving the problems connected with, the new materials of construction. The focus on the skyscraper as the source of innovation obscures the important role government played in advancing building technology, as a patron and a regulator.

By 1910, the fireproof building was largely perfected. Fireproof buildings had proved themselves in the great conflagrations in the first decade of the century. Fireproof building methods were becoming the standard methods of construction, as the cost of building fireproof declined and the scope of laws expanded so that more kinds of buildings were required to be fireproof, besides tall ones.

To retrace our steps for a moment, until the early part of the twentieth century, fireproof construction was much too expensive for many kinds of buildings, including some containing very hazardous activities. One of the most hazardous buildings was the textile factory. A system of fire resisting construction was developed in New England for textile mills that was an alternative to fireproof construction, called "slow-burning construction." Chapter 5 chronicles the development and legacy of this system. A standard slow-burning mill by the end of the century had masonry walls with a heavy timber frame inside, an internal fire suppression system, and well designed egress facilities. This system of construction left an important legacy in the form of automatic sprinklers, which were perfected for slow-burning mills precisely because the mills were not fireproof. Also, the underwriters who insured the New England mills developed a novel philosophy of insurance, which held that the role of the underwriter was to reduce loss as much as to indemnify against it. The stock-company underwriters eventually adopted this philosophy, although to a lesser extent.

More Hard Lessons: Attention Shifts to Life Safety

By the end of the century, some cities had quite elaborate rules governing the construction of buildings in the fire limits. Whether the rules were enforced is another question. But neither rules nor enforcement were well developed with respect to the third fire safety issue, which is safety to life. More than any other means, this is accomplished through adequate egress. Exits must be able to handle a crush of people even at a false alarm. As discussed in the concluding chapter, lawmakers had long recognized that egress was part of the fire safety picture. Egress, like the materials of exterior walls, was a public safety issue:

the reason the laws required adequate egress was not so that a building owner can escape, but so that the public who used his building could. The public could no more depend on the goodwill of the owner to provide adequate egress than to build masonry walls or fireproof his columns. Even as fire insurance rates began to vary according to the fire resistance of and safety equipment in the building, giving an owner at least some financial incentive to build better, nothing, financially speaking, encouraged an owner to protect the lives of strangers or to devote valuable space inside a building to something as unremunerative as stairways. Fire insurance rates likewise took no account of the adequacy of egress because insurance policies covered property, not lives. Only public intervention could address this matter.

However, much less attention was given to emergency egress than to fireproof construction, either by building interests or lawmakers. Laws required "adequate" egress in certain kinds of buildings, i.e., tenement houses, hotels, theaters, places of public assembly, and factories, where large numbers of people gathered. With the exception of theaters and similar buildings, the adequacy of facilities was left to the discretion of building inspectors to determine. In other words, the law might say that fire escapes were required, but not specify the dimensions, design, or strength of acceptable fire escapes.

Emergency egress was not considered an issue for tall buildings, as such. By the early twentieth century, the majority of the tall, fireproof buildings were office buildings and were considered low risk for fire inside. Moreover, in theory, the occupants of such buildings could escape a fire by going from the burning floor to the next one; the fire should not be able to pass through the floor or up the stairway or elevator shaft, since these were required to be covered with fireproof doors.

The technology of the fire resistant building had advanced the hard way, and the process of by which safeguards to human life advanced was no different. A turning point occurred in 1911. A fire in a tall building caused the deaths of 146 people who could not escape from the upper floors in fire because of inadequate egress. But the building, which was fireproof, suffered little damage. This was the Triangle Shirtwaist fire. After this tragedy, lawmakers began to give more serious attention to egress and to require the automatic sprinklers perfected in New England in slow-burning mills. A new object was added to the purposes of the fireproof building: to safeguard the lives of the occupants of the

building.

Research Methods and Organization of this Study

While fireproof buildings have been covered to some extent by other writers, this study is the first comprehensive treatment of the history of American fireproof construction in the nineteenth century.¹⁵ One of the greatest problems in doing this study has been compiling a inventory of fireproof buildings in all periods. Fortunately, it is not necessary to guess or infer which buildings were fireproof, since fireproof buildings usually were identified as such by contemporaries.

However, the task of learning the particulars of how they were constructed has been an arduous one. It is extremely difficult to get accurate and complete information on how buildings were built. Collections of architectural materials focus on the exteriors and furnishings of buildings, not on their structures. Moreover, most of the nineteenth century fireproof buildings are gone. But even when the buildings are still standing, it is not easy to find out what is going on, structurally speaking, under the floor boards and behind the walls. Nevertheless, I have tried to track down every building that was identified as fireproof by nineteenth century authorities or that I suspected might be fireproof, at least for the period before 1870, after which they become too numerous to inventory. I do not know how many pre-1870 fireproof buildings I failed to locate; and since the universe of fireproof buildings is unknown, I can not even say that my sample is statistically representative. Nevertheless, there was much documentary evidence to corroborate the conclusions I drew based on the sample I did collect. I should say, too, that with the exception of tall apartment houses and hotels, residential buildings rarely were built with fireproof building methods, consequently the focus of this study is on non-residential, principally commercial, buildings.

How did I find fireproof buildings and learn the details of their construction? For the period before the 1850s, when contemporary information is slight and too scattered to collect in any efficient way, I relied on secondary sources, mainly biographies of architects, both to

¹⁵ Fireproof construction is treated in a number of works: Cecil D. Elliott, Technics and Architecture (Cambridge: M.I.T. Press, 1992); Carl Condit, American Building, 1982; Henry Cowan, Science and Building (New York: John Wiley & Sons, 1978); and S. B. Hamilton, A Short History of the Structural Fire Protection of Buildings Particularly in England, National Building Studies, Special Report No. 27, Department of Scientific and Industrial Research (London: HMSO, 1958).

locate fireproof buildings and to find out how the buildings were constructed. Because of the sources I used, the buildings I discuss will be familiar to architectural historians. For the decades of the 1850s and 1860s, the period of the iron and brick arch fireproof building, I used two sources mainly. One was the Records of the Public Building Service, formerly the Construction Branch of the U.S. Treasury Department, at the National Archives in Washington, which contains very complete information on fireproof federal buildings. A second valuable source of information was the Cooper Hewitt Collection in the Manuscript Division of the Library of Congress. This collection contains order books, day books, and shipping records of Trenton Iron Works, which was owned by Cooper, Hewitt and Co. During this period, Trenton Iron Works was briefly the only, and later one of only a handful, of companies that produced rolled iron beams, a key ingredient of fireproof buildings. These records provide a detailed picture of what products were sent to what customers.

In the last two decades of the century, American architectural and engineering periodicals are available. For this period and the first decade of the twentieth century, I used magazines such as American Architect and Building News, Inland Architect, and The Brickbuilder as well as trade magazines, engineering magazines, and proceedings of professional organizations. For standing buildings, I consulted the records of the Historic American Buildings Survey. I have tried to obtain information from the owners of extant fireproof buildings and have inspected many of them.

Although I am writing about buildings, this study not architectural history. Nevertheless, I hope my study will be of value to architectural historians and preservationists, builders, architects, and others involved with building renovation, to help them recognize fireproof construction methods, evaluate the significance of the structural systems of buildings, and preserve important examples.

Conclusion

The development of the materials and methods of fireproof construction had significant consequences for American building construction, not to mention for the safety of America's downtowns. The materials perfected for constructing fire resistant buildings -- structural metal, hollow tile, and concrete -- became the standard materials for commercial buildings in the early twentieth century. This study describes the evolution of the technology

and the factors that impelled its advance, including the role of government.

That this development owed much to government might seem surprising. Government contributed in several ways: as a client for fireproof construction, at a time when few private owners were interested; by sponsoring tests of materials of construction; and through regulation. This last point may seem counter-intuitive, since it is more usual to assume that government regulation inhibits innovation. True, regulations were hardly very strict through most of the period covered by this study, and everywhere, it seems, rules were indifferently and variably enforced. Still the laws of the cities with the most advanced codes did much to spread and standardize the new fireproof construction methods. The technical detail of America's more sophisticated building laws at the turn of the century, for example the laws of Boston and New York City, were a wonder to British architects,

in ... the compulsory fireproofing of certain buildings, the provisions of means of escape, and the detailed regulations for safe construction, the American requirements are of much more far-reaching character than our own.¹⁶

The laws provided the less technically self-sufficient members of the profession with an "authoritative and useful hand-book for general reference and a valuable help in many details of special construction."¹⁷

One of the things this study intends to show is how failure shaped both the technology and law. In America, for example, the front doors of public buildings open outward, or swing both ways or turn. They are this way because of lessons that were learned, the way so many lessons in the field of fire safety were learned, the hard way. This study tries to bring to light the long-forgotten background of these rules.

Then as now, the laws had their critics, who charged that they stifled innovation and individual problem-solving. But then as now, this complaint is more theoretical than real.¹⁸ The frequency with which codes in places like New York, where every inventor hoped to

¹⁶ Horace Cubitt, "A Comparison of English and American Building Laws," AABN vol. 89 (May 19, 1906), p. 180.

¹⁷ AABN vol 38 (Nov. 5, 1892), p. 18.

¹⁸ Francis Ventre, Social Control of Technological Innovation, examines the question of whether regulation as applied to home building restricts technological innovation. He concludes that it does not, even if the speed of code modification is not acceptable to the actors most likely to benefit from the changes.

introduce his new product, were revised in order to accommodate new materials and practices is amazing. Nineteenth century codes were defective in many respects: they were for the most part collections of rules without any order, with often obscure and contradictory provisions; very likely they required some measures that increased cost but did little to achieve the desired objective.

That the laws accomplished much, despite their imperfections, is apparent in the nation's fire record. The last great urban conflagration in the U.S. was the one following the earthquake in San Francisco in 1906. Although Americans continue to die in fires, the trend over the century, in absolute numbers, has been downward. Even the number of fires in structures has declined and the downward trend continues today, dropping from over a million in 1980 to 638,000 in 1992.¹⁹ Today, with respect to fire safety, Americans are at less risk in public, code-complying buildings in center cities than they are in their own homes.

¹⁹ U.S. Bureau of the Census, Statistical Abstract of the United States: 1994, (Washington, DC, 1994), table no. 349.

Chapter 2.

The Solid Masonry Fireproof Building, 1790-1840

Introduction

English colonists were just beginning to build their homes on the peninsula that became Boston, Massachusetts when Governor Dudley, in an effort to reduce the danger of fire in the young settlement, forbade the use both of wood in constructing chimneys and thatch for covering roofs.¹ The first Dutch settlers in Manhattan likewise had to construct their chimneys to the satisfaction of municipal officers and, by the eighteenth century, were not allowed to erect buildings with wooden walls within designated fire limits.² Fire safety laws are among the oldest examples of the exercise of local police power.

Early fire laws typically restricted dangerous behavior and prescribed the materials, form, and location of buildings. The 1810 fire law for Charlestown, Mass., for example, covered all these matters. It defined a district -- what came to be called the building or fire limits -- within which residents were forbidden to construct "public buildings" unless all exterior walls were made of brick or stone. Except for one story buildings, all others had to have a long wall or end walls of brick or stone. It specified the minimum thickness of masonry walls. It also fined certain activities, such as smoking in barns and carrying open flames in the street. The law also required houses to have a hatch, called a "scuttle," with a ladder leading to it, and railing on their roofs for emergency exit.³

The fire laws were generally the only regulations that dealt with building construction. When a community's various fire safety rules were collected, they constituted what came to be called a building code. The laws were usually administered by fire officials; even

¹ Notes on the Development of Early Architecture in Massachusetts, Historic American Buildings Survey, 1941.

² Joseph McGoldrick et al., Building Regulation in New York City (New York: The Commonwealth Fund, 1944), pp. 71-72.

³ "An Act for the better security of the town of Charlestown against fire," Chapter 44 of Massachusetts Acts 1809.

agencies established specifically to inspect buildings often were divisions within municipal fire departments. Unlike the "surveyors" in London, who were architects or builders, American fire wardens and inspectors did not have any special qualifications, and were chronically understaffed. Laws permitted non-complying structures to remain provided the owner paid a penalty, and often legislatures relaxed laws passed in response to citizens' protests. After a devastating fire in 1679, Bostonians refused to rebuild their houses in costly brick or stone in defiance of an order of the colonial legislature.⁴

However, even if the laws requiring masonry walls had been observed, the danger of conflagration would have persisted since wood was the main component in every building. Boston's history, again, illustrates this point. After 1803, according to an early chronicler of the city, officials began to enforce the prohibition against wooden buildings.⁵ Eventually the character of the downtown changed from residential to commercial and filled up with substantial-looking stone and brick buildings. But behind the masonry walls were wooden frames; the beams, joists, posts, roof frames, and interior partitions as well as window frames, doors, cornices, cupolas, and spires were made of wood. Boston's "granite buildings" virtually melted in the great fire of 1872.

The challenge for building owners wishing to safeguard their properties was to find a way to protect wood or else to replace it with some noncombustible material. Besides masonry walls, roofs boards were covered with slate, tile, and metal plates, sometimes laid in a bed of mortar for good measure, to protect a roof from being set afire by sparks. Wood gutters, cornices, and shutters could be replaced with metal ones. But for the spanning parts of buildings, finding a substitute for a material as cheap, workable, and strong as wood was difficult. Thus, some of the earliest fire protection strategies involved sheathing wooden structural members with, for example, thin metal plates; filling between joists with mixtures of mortar and other ingredients; or saturating wood that great, but never realized, desideratum,

⁴ Records of the Governor and Company of the Massachusetts Bay ..., 1854, pp. 239-40.

⁵ Caleb H. Snow, A History of Boston 2nd edition (Boston: Abel Bowen, 1828), p. 326.

fireproof paint.⁶

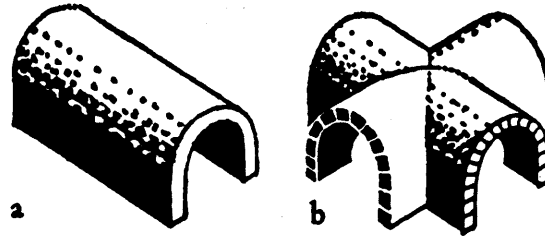
Because none of these expedients guaranteed security, some building owners pursued other courses. One was to build a fireproof room for safekeeping in an otherwise ordinary building. These rooms had thick masonry walls and were roofed with brick; all openings were covered with iron doors. A masonry ceiling, such as in these rooms, is called a "vault." *Vaults* can be constructed in a variety of shapes, the simplest and most commonly used in the United States were barrel or intersecting (groin) vaults. (Illustration 2-1.) Vaults invariably were arched, so that the small pieces of masonry that made the arch -- the bricks or stone -- rested on each other and eventually on the walls; they were also held together and in place by some adhesive substance -- mortar or cement. It is probably because of their origin in these special masonry rooms that secure rooms for storing valuables to this day are called "vaults." Contemporaries sometimes referred to them as "fireproofs." Examples include the two fireproof rooms in the second Massachusetts State House; two rooms under the stairs of the portico at St. Paul's Church in Boston; and a room in the Arch Street Friends Meeting House in Philadelphia.⁷ By concentrating expensive, noncombustible material in one room, a property owner could safeguard his most valuable possessions at less expense than protecting an entire building. This strategy of building rooms into otherwise ordinary buildings continued to be followed through the first three quarters of the nineteenth century at least.

The second, and more secure, method was to build the whole structure of masonry -- to make a solid masonry, or vaulted, building. Since no wood was used structurally, these buildings were the first kind of fireproof building in America.

⁶ A kind of interlocking iron plate invented by David Hartley enjoyed some popularity in England at the end of the 18th century and beginning of the 19th. At about the same time, a mixture of lime, sand, and chopped hay was introduced to protect floors. Both are described in Associated Architects, Resolutions...with the Report of a Committee...To Consider the Causes of the frequent Fires, London, 1793.

⁷ The rooms in the Massachusetts State House, which no longer exist, projected from the rear of the building at ground level and can be seen on old plans of the building. St. Paul's Church is still standing; I inspected the fireproof rooms. The vaulted, fireproof room in the 1803-05 Arch Street Meeting House in Philadelphia, is described in James O'Gorman et al. Drawing Toward Building (Philadelphia: Pennsylvania Academy of the Fine Arts, 1986), pp. 49-50.

Illustration 2-1. Barrel (a) and groin (b) vaults.



Sources of the Solid Masonry, or Vaulted, Fireproof Building

Solid masonry, or vaulted, fireproof buildings first appeared in Great Britain in the mid-eighteenth century. At about this time, the prolific English architectural writer Batty Langley suggested that wood be discarded in order to "prevent the sad consequences of fire in dwelling-houses." According to Langley, a fireproof building would have "brick floors, with arches, groined, or coved ceilings," as well as stucco trim, stone staircases, brick interior partitions, and a lead covering over the roof.⁸ He advocated the system for houses of the nobility but did not list any examples of such houses in his book, so he may have been making a recommendation rather than describing an actual practice.⁹ While masonry vaulting is an ancient construction technique, it was not employed in ordinary buildings. The spanning parts of buildings in Britain, as in the U.S., typically were made of wood.

Another writer who advocated a masonry fireproof building was the former army officer Count Felix-Francois d'Espie. His book titled Manner of Securing All Buildings from Fire was translated from the French and published in England in 1756. He built a house in

⁸ Batty Langley, The London Prices of Bricklayers Materials and Works (London: Richard Adams and John Wren, 1749), p. 246.

⁹ Isolated houses, whether owned by the rich or poor, were very hard to save once they caught fire. Undoubtedly some estate owners rebuilt their fire damaged mansions fireproof.

Toulouse with the masonry walls, interior partitions, arched floors, and roof he advocated.¹⁰

The vaulted type of fireproof building that were built in England about this time were small structures, but soon the vault system was also applied to large buildings. Early examples are several small, solid masonry industrial buildings at the Royal Dockyards. Also at the dockyards, cellars in some warehouses were built with ceilings of brick vaults, to create secure rooms for flammable stores.¹¹ The practice of building vaulted cellars in warehouses became common in Britain and continued well into the nineteenth century.¹² Large vaulted buildings include several designed by the architect John Soane for the Bank of England, the first of which was the Stock Office of 1792.

But the vault system had many drawbacks which limited the adoption of the system. The principal problem was spanning large areas with small, heavy structural units: bricks. The great weight of wide brick vaults led to a few disasters. Another of the large vaulted buildings was a new Custom House in London, designed by one of Soane's students, David Laing. (Illustration 2-2.) The building settled unevenly and in 1825 the floor over the vaulted central section collapsed.

To lighten the vaults, some architects used hollow masonry building blocks, an ancient building material that recently had been revived by French architects for fireproof construction in Paris. (Illustration 2-3.) Soane in fact had used hollow terra cotta "arch pots"¹³ to lighten the dome in his Bank Stock Office and arch pots were manufactured in England in the 1790s. One authority states these pots were "extensively used at one time" and lists Buckingham Palace, National Gallery, the Treasury buildings, and the United Service

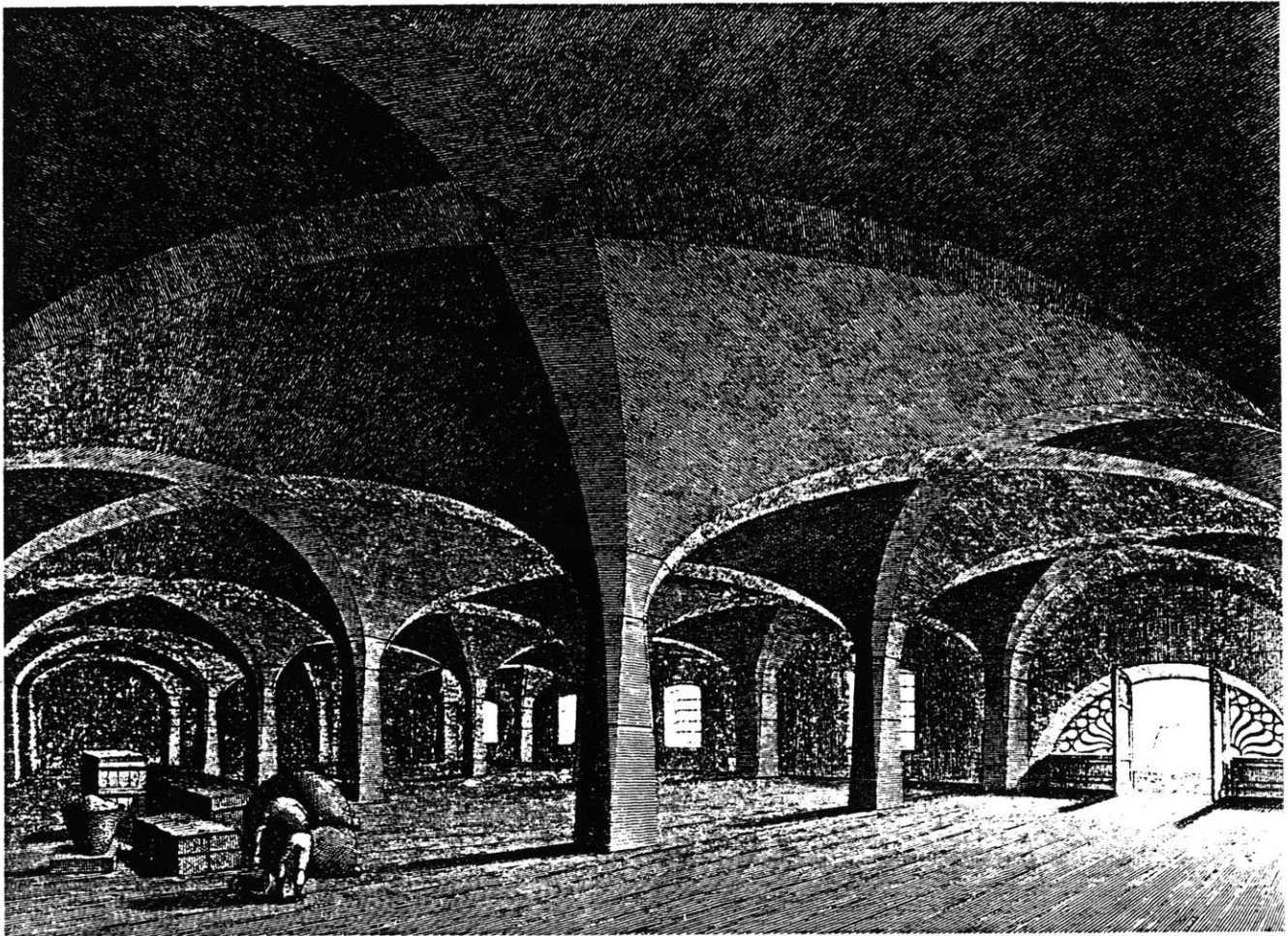
¹⁰ Eileen Harris, British Architectural Books and Writers 1556-1785 (Cambridge: Cambridge U. Press, 1990), pp. 190-191.

¹¹ J. G. Coad, "Two Early Attempts at Fire-Proofing in Royal Dockyards," Post-Medieval Archaeology vol. 7 (1973), p. 88.

¹² For example, some of the London warehouses built between 1840 and 1860, which were destroyed the Tooley Street fire in 1861, had vaulted cellars. Building News, vol. 7 (July 5, 1861), p. 573.

¹³ Dorothy Stroud, Sir John Soane Architect (London: Faber & Faber, 1984), p. 156.

Illustration 2-2. The King's Warehouse, 1813-17, London.



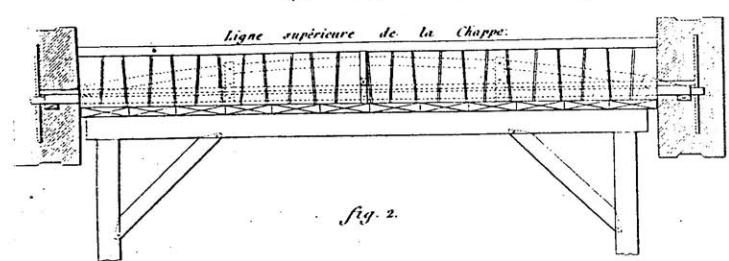
Club as having floors made of arch pots.¹⁴ This claim is probably an exaggeration, since the buildings listed as having these floors are hardly ordinary structures.

Indeed, the solid masonry system never caught on in England. Comparing the vault system with new methods of fireproof construction available in England by 1819, the British engineer Charles Sylvester concluded, "(vault) buildings are very uncommon, very expensive, and the principle upon which they are constructed is not at all adapted for the common

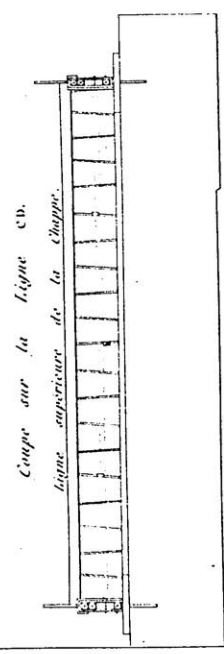
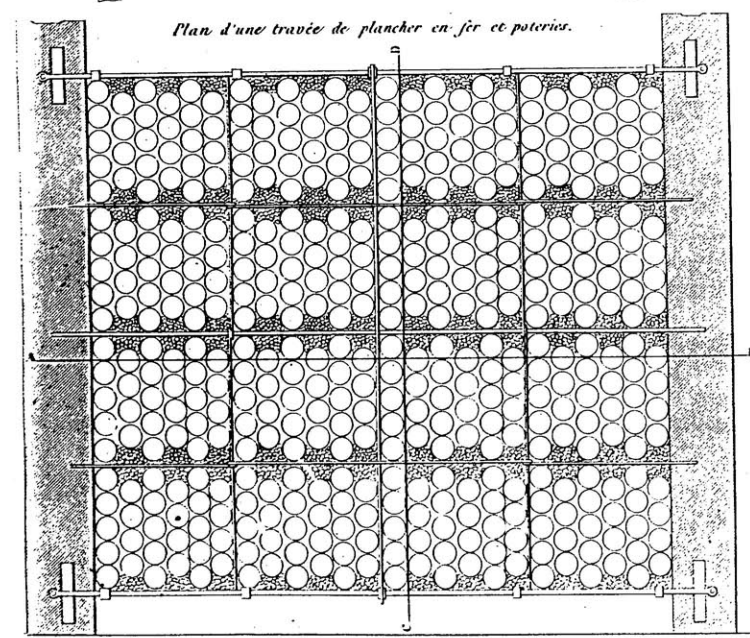
¹⁴ John J. Webster, "Fire-proof Construction," Minutes of Proceedings of the Institution of Civil Engineers vol. 12 (1890-91), pp. 264-265.

Travée de plancher en fer et poteries.

Coupe sur AB.



Plan d'une travée de plancher en fer et poteries.



Coupe d'une Voûte (plein cintre.)
bandée en poteries et plâtre. (sans fer.)

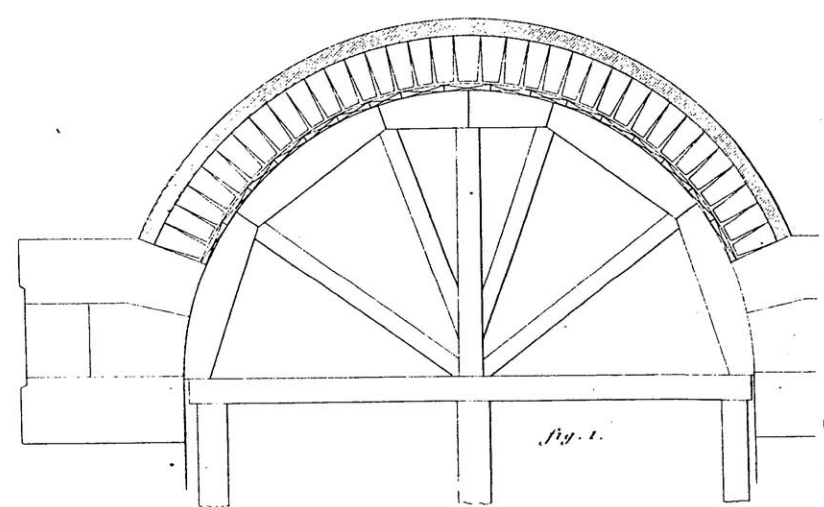
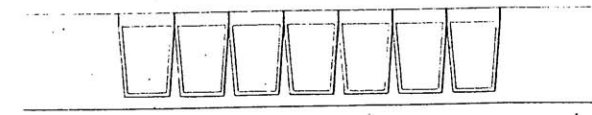


fig. 3.

Coupe de pots creux assemblés et confectionnés de manière à servir de Carreaux pour la partie supérieure d'un plancher.



Echelle de 1 2 3 4

(Nota) Les Carreaux en fer, dans les systèmes de Voûtes autres qu'en plein cintre exigent une position d'Etablissement, analogue à celle généralement nécessaire aux planchers; elles doivent donc être noyées dans l'épaisseur de la Contrefort en poteries.

purposes of life."¹⁵

In approximately the last quarter of the eighteenth century, when British designers were beginning to experiment with using iron for fireproof construction, the masonry vaulted system made its way to America. The U.S. was not a hospitable place for an unusual masonry construction technique; wood was the principal building material and carpenters greatly outnumbered all other building tradesmen.¹⁶ Vaults of any kind, even in building foundations, were rare in the United States in the eighteenth century. The few large buildings of the time -- the north wing of the U.S. Capitol in Washington, Independence Hall in Philadelphia, and the second State House in Boston -- all had interior frames made of wood. Nevertheless, the advocates of fireproof construction designed vaulted buildings and got them built, even if they had to train the workmen themselves. The vault system continued to be used in the U.S. long after British designers had abandoned it except for constructing warehouse cellars. Solid masonry buildings were the standard fireproof buildings in the United States until the middle of the century.

Perhaps the first American solid masonry fireproof building was the Walnut Street Jail in Philadelphia, begun in 1774 and completed in 1785.¹⁷ The jail was a large structure for its time, intended to replace a decrepit prison that the city had outgrown. It was designed and, until his death, built by Robert Smith (1722-1777). Smith was born in Scotland into a family of masons and had apprenticed in the building trades before relocating to Philadelphia as a young adult. He became an important builder in Philadelphia, a leader in the Carpenters' Company, and he designed a number of prominent buildings.¹⁸ The jail was a two story, U shaped stone building, and its most notable feature was its masonry fireproof floors, formed

¹⁵ Charles Sylvester, The Philosophy of Domestic Economy (London: Longman, Hurst, Rees, Orme, and Brown, 1819), footnote pp. 7-8.

¹⁶ Louise Hall, "Artificer to Architect in America," PhD dissertation, Radcliffe College, 1954, p. 63.

¹⁷ Throughout the text, the dates listed for buildings include the period from design to completion, where it was possible to learn these years.

¹⁸ Philadelphia Museum of Art, Philadelphia, Three Centuries of American Art, 1976, pp. 31-32.

of intersecting (groined) or barrel vaults. As described in 1798, "there are eight rooms upon each floor all groin arched for the two fold purpose of *securing against fire and escapes...*"¹⁹

The jail was enlarged in 1790, when a fireproof prison block -- the ancestor of the penitentiary -- was added. Pennsylvania's just enacted penal code provided for incarceration at hard labor rather than corporal punishment for the state's serious offenders. Recalcitrant prisoners were to be held in solitary cells, hence the new cell block. It was to be constructed of brick and stone, "upon such plans as will best prevent danger from fire" and was also a vaulted structure.²⁰ Buildings for holding the infirm or incarcerated -- people who could not easily escape in an emergency -- were among the most likely ones to be built fireproof.

Latrobe and His Students to the mid-1830s

The true beginning of the history of the solid masonry system dates from the arrival of Benjamin Henry Latrobe (1764-1820) in the U.S. in 1796. The men who designed vault building were among the most accomplished of America's early architects, including Latrobe and his students. He was influential in two respects. First, his solid masonry buildings were models of how to build vault buildings. Latrobe was the first architect here to build prominent, vault buildings, and his vaulted work on the Capitol was seen by several American architects who went on to designed vault buildings. Second, he was important as a teacher. Two of his students became important practitioners of vault construction. Already an experienced architect when he emigrated from Britain, Latrobe brought knowledge of vault construction with him. His first major commission was a prison in Richmond, Virginia in 1797. The Virginia legislature had recently revised its penal code, following the direction set by Pennsylvania, and ordered an appropriate facility to be constructed.²¹ Latrobe designed a horseshoe shaped cell block in which all the cells were vaulted. While the building was still

¹⁹ Reprint of article from the Philadelphia Monthly Magazine, 1798, in the appendix of Negley Teeters, The Cradle of the Penitentiary; The Walnut Street Jail at Philadelphia, 1773-1835 (The Pennsylvania Prison Society, 1955), p. 130. Teeters is my source for information on the Walnut Street jail.

²⁰ Negley Teeters, Cradle of the Penitentiary, quote from Act of 1790, p. 40.

²¹ Editorial comment in Edward Carter, editor-in-chief, The Papers of Benjamin Henry Latrobe series IV, vol. 1 (New Haven: Yale University Press, 1984), pp. 39-40.

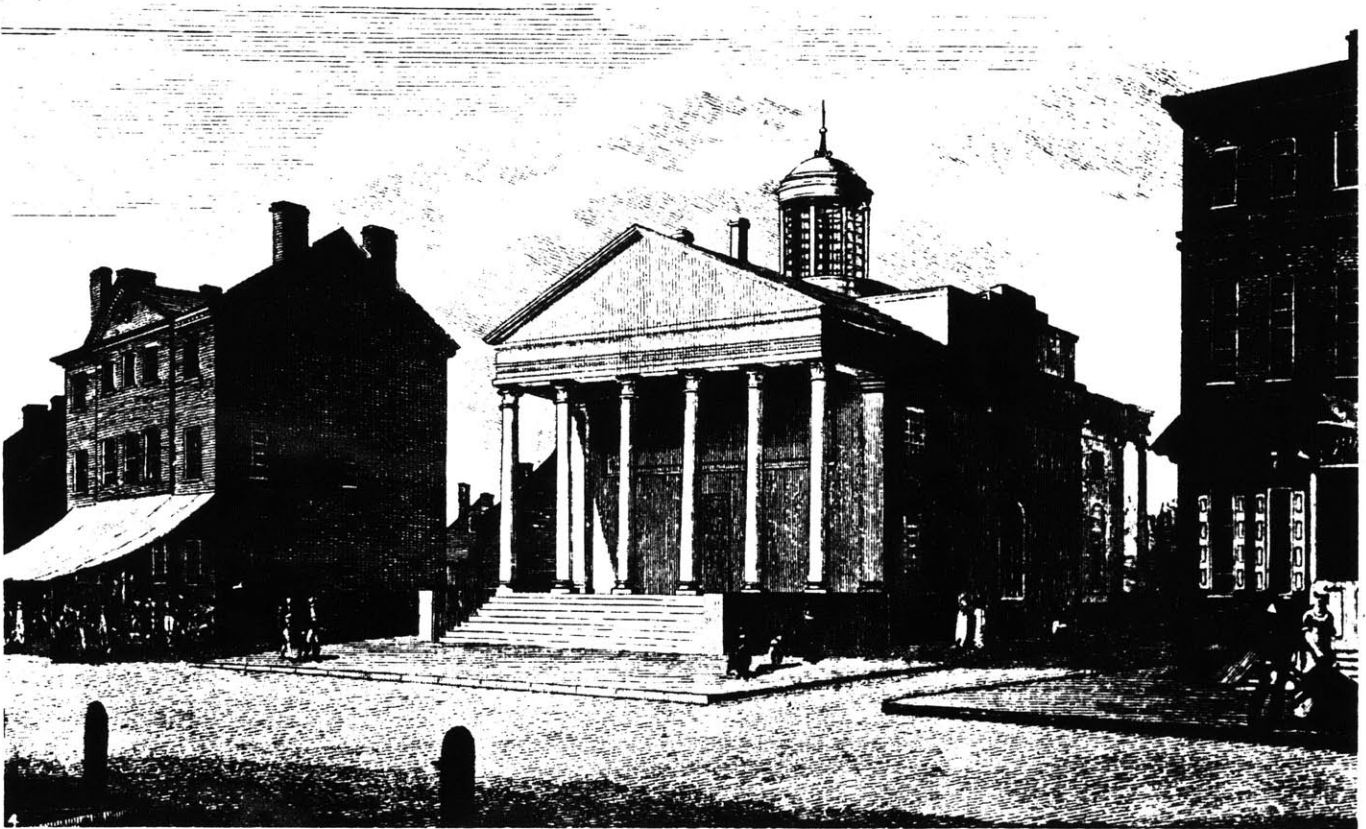
under construction in 1798, Latrobe visited Philadelphia, partly to see the Walnut Street jail and partly to seek additional architectural work. He succeeded in obtaining a commission to design a private bank in Philadelphia, the Bank of Pennsylvania. Banks, like custodial institutions, were a kind of building that often were fireproof. Latrobe moved to Philadelphia to superintend the construction of the bank, and the Virginia Penitentiary was completed by someone else and not according to Latrobe's original plans.²² The Bank was completed in 1801.

Latrobe designed a fireproof building for the Bank, which in its three section plan was similar to Soane's 1792 Bank Stock Office. The front and rear part of the rectangular building were small vaulted rooms, and in the center was a circular banking hall covered by a masonry dome with a cupola in the peak. The vaults and dome were built in brick, and as such necessitated massive walls to resist the weight and outward thrust of the arches. Latrobe did not follow Soane's example in using arch pots. There is no evidence that this material was ever made in, or even imported to, the U.S., although clay products -- brick, structural tile, and terra cotta ornaments -- came to be used to a large extent in fireproof buildings. The dome, associated with Roman architecture, was a historically inaccurate feature on a building with a severe Greek (Ionic style) porch. However, the only ways to cover a large space with masonry was with some sort of arch or dome, neither of which would have been accurate. It was undoubtedly as a solution to the problem of spanning a room with masonry blocks that many of the "Greek" fireproof buildings of the period contained vaults and domes. (Illustration 2-4.)

Roofs presented an aesthetic as well as a technical problem for designers of the vault buildings who wished to design in the popular Greek style, since arches are not characteristic of classical Greek buildings. Purists disparaged the fireproof buildings, which combined Greek orders and "Roman" domes and vaults, implying that their designers were poor students of classical models. The combination continues to puzzle architectural critics. Paul Goldberger described the rotunda of the 1830s New York Custom House as "incongruous and

²² Edward Carter, Papers of...Latrobe, footnote p. 40.

Illustration 2-4. Bank of Pennsylvania (1798-1801), Benjamin Latrobe.



excellent."²³ Some historians have explained the combination of classical styles as deliberate and certainly not ignorant. According to George Tatum, for example, nineteenth century architects came to believe that art embodied the values of the culture in which it was created. They chose Greek and Roman styles because they approved of the values of these cultures and hoped in using them to create buildings that would instruct and elevate the feeling of the viewers. In their hands, classicism was "for a time a phase of Romanticism,"²⁴ and exact reproduction was less important than creating an effect.

²³ Paul Goldberger, The City Observed: New York (New York: Vintage Books, 1979), p. 21.

²⁴ George B. Tatum, Penn's Great Town (Philadelphia: U. of Pennsylvania Press, 1961), p. 54.

But there may be a more practical explanation for these seemingly anachronistic hybrids: domes and vaults were about the only way to span large areas using small structural units like bricks. Brick was used, of course, rather than wood -- the authentic material for a Greek roof -- in order to make the buildings fireproof. Where the roofs on fireproof buildings were not domes or vaults, they were made of wood. An architect either had to sacrifice historical accuracy and achieve a thoroughly fireproof building or place a wooden roof on a historically accurate but not thoroughly fireproof building. The latter route was frequently taken for economic as well as aesthetic reasons, because vaulted roofs added considerably to the cost of a building. There was one solution to the Greek style dilemma that involved no compromises -- on the exterior of a building at least -- and that was to place a pitched, wooden roof over an interior vault. But noncombustible coverings put on wooden roofs unfortunately were not as watertight as traditional materials. Latrobe used lead coverings on some of his fireproof buildings, following English practice, but he found that in the U.S., where temperature variations were much greater, lead plates warped and water came in the gaps. He also tried iron plates, but these leaked too.²⁵ Slate was the most common fireproof covering, although it eventually was discarded as a hazard in a fire. For some reason, most likely because it made a very heavy roof covering, tile was never a popular roofing material in the U.S.

Latrobe constructed a number of fireproof buildings for the national government between 1803 and 1811. He was appointed surveyor of public buildings by President Jefferson, who was acquainted with his Virginia prison. In this position, Latrobe superintended the construction of the partially complete south wing of the U.S. Capitol, for which he specified vault construction, and the fireproof addition to the Treasury Department building, constructed in 1805-06. In both buildings, Latrobe fitted vaulted structures inside facades designed by other men. The Treasury building had suffered a fire in 1801 and

²⁵ In an 1814 letter with advice on how to make a roof fireproof, Latrobe wrote that the sheet iron he put on the roof of Nassau Hall at Princeton University, reconstructed after a fire in 1802, was as good as the day it was finished. But, in fact, it leaked. (Talbot Hamlin, Benjamin Henry Latrobe (New York: Oxford University Press, 1955), p. 192 and 422.)

Jefferson designed the extension for safekeeping of important papers.²⁶ Latrobe roofed this one story, rectangular building with a shallow vault, tied with iron rods.

The last of Latrobe's fireproof government buildings of this period was the custom house in New Orleans, for which he received a commission in 1807. He designed a masonry building with a vaulted ground floor. Unfortunately, this heavy building, like Laing's Custom House in London, settled unevenly in the city's compressible soil and the walls cracked.²⁷ Because maintenance was put off -- other matters taking precedence during the War of 1812 - the building fell to ruin. It was replaced in 1819, only ten years after it was completed.

Latrobe left government employ during the War, but returned to Washington in 1815 when he was hired to reconstruct the buildings destroyed by the British in 1814. To his satisfaction, no doubt, his sections of the Capitol as well as the fireproof wing of the Treasury building survived the attack.²⁸ But he resigned in 1817 amid charges of extravagance, something practically every architect who did government work was accused of, whether justified or not.

Latrobe began designing vault buildings as soon as he arrived in the U.S., though vault buildings were rare in England and it is not clear how he learned the technique. He gives a hint in an 1806 entry in his journal, where he wrote that his natural genius enabled him to pick up "the methods, the tricks, and the knacks of workmen with the technical vocabulary belonging to them."²⁹ He must have learned the practicalities of construction from observing tradesmen at work, but he apparently did not have a background in the trades himself. Sometimes his vault projects failed while under construction. A vaulted loggia that connected the fireproof Treasury wing with the President's house in Washington collapsed

²⁶ Talbot Hamlin, Latrobe, pp. 293-295.

²⁷ Talbot Hamlin, Latrobe, pp. 295-296.

²⁸ Latrobe's wing was standing in 1833 when the Treasury burned down again, and, according to Robert Mills, also survived this second test, although the rest of the building was destroyed. (Mills to Secretary of the Treasury [Louis McLane], April 6, 1833, The Papers of Robert Mills, 1781-1855, microfilm roll 6.)

²⁹ Edward Carter, editor, The Virginia Journals of Benjamin Henry Latrobe 1795-1798 (New Haven: Yale University Press, 1977), p. 48.

after the centering was removed. When informed of the disaster, Latrobe wrote to the clerk of works, John Lenthall, "I am very sorry the arches have fallen, both on account of the expense & the disgrace of the thing. But I have had such accidents before, and on a larger scale, & must therefore grin & bear it."³⁰ Presumably he was less stoic in 1808, when the vaults in the basement of the Capitol collapsed, also when the centering was removed, and crushed his faithful clerk of works to death.³¹ Whether these collapses and cracked walls were attributable to defects in Latrobe's design or in the execution of the work, is impossible to say. The potential for failure was much greater in these novel buildings than in traditional buildings. Nevertheless, the vault system spread in the U.S.

One of the staunchest advocates of fireproof construction among the second generation of vault builders was Robert Mills (1781-1855), a student of Latrobe. While Latrobe considered himself an artist whose buildings incidentally were fireproof, Mills seems to have considered himself a designer of fireproof buildings that incidentally were aesthetically pleasing. Because he was so prolific, he helped define what was meant by the term "fireproof building." Mills was a native of South Carolina and, unlike most American-born architects of this period, had no background in the building trades. He worked in Latrobe's office from 1803 to about 1809, having been referred to Latrobe by his patron, Thomas Jefferson. One of Mills' last assignments as Latrobe's assistant was to superintend the construction of the vaulted Philadelphia Bank (1807-08), which he wrote contained "novel forms of the vaultings and great span of arches in the center hall, all of which were built of solid masonry and made fireproof."³² He considered this bank his first fireproof building.³³

Mills' earliest projects, after setting up his own practice, were for fireproof buildings. He designed a jail for Burlington County in New Jersey in 1808, and in a letter

³⁰ Letter dated December 31, 1806, quoted in Talbot Hamlin, Latrobe, p. 295.

³¹ Edward Carter, editor, The Journals of Benjamin Henry Latrobe 1799-1820 vol. 3 (New Haven: Yale University Press, 1980), footnote p. 73.

³² From Mills autobiography, reprinted in H. M. Pierce Gallagher, Robert Mills (New York: Columbia University Press, 1935), p 159.

³³ U.S. House of Representatives, Report No. 737, "New Treasury and Post Office Buildings," March 29, 1838, p. 28.

accompanying his plan explained that the building should be fireproof,

There should be as little combustible materials used in its construction as possible. ... Humanity as well as Interest plead in favor of this, when we refer to the many melancholy Instances on record of persons confined, perishing in the flames from inattention or being forgotten during the Confusion...³⁴

Like the Walnut Street Jail and Latrobe's Virginia Penitentiary, Mills' prison had vaulted cells. Another project was a design for fireproof wings to replace the porches flanking the Pennsylvania Statehouse (now Independence Hall) in Philadelphia (c. 1812), "for the deposit of the records of the said City and county."³⁵ These two blocks were unusual because they were domestic in scale -- more like ordinary houses than the banks and prisons that had heretofore been built fireproof. There is no other example of a vaulted block like this, except perhaps for a vaulted house in Philadelphia designed by Latrobe in 1804.³⁶ When the superstructure of Mills' Statehouse wings was demolished in 1896, an engineer calculated that the vaults weighed an enormous 217 pounds per square foot.³⁷

Mills went on to design many prominent fireproof buildings in South Carolina in the 1820s while holding the position of architect and engineer for the state. The original building at the State Hospital for the insane in Columbia (1821-27) was a "thorough vaulted fire-proof structure," built this way at Mills' urging, "in consequence of the helpless character of its inmates."³⁸ It had iron window frames and shutters, an idea that may have been borrowed from England where cast iron sash was used, for example, in the 1818 Cornwall Country

³⁴ Letter to the Building Committee of Burlington County Prison, June 4, 1808, The Papers of Robert Mills, microfilm.

³⁵ James O'Gorman et al., Drawing Toward Building, p. 61.

³⁶ Talbot Hamlin, Latrobe, pp. 196-97. The only evidence that this building existed is that it is mentioned in an 1811 letter from Latrobe.

³⁷ Edwin Betolett, "Fireproof Construction in Philadelphia," Insurance Engineering vol. 2 (1901), p. 200. Parts of the vaulted cellars of these buildings still remain. (Correspondence from Tom McGimsey, Historical Architect, National Park Service, June 24, 1993.)

³⁸ Mills' report in U.S. House of Representatives, Report No. 737, 1838, p. 22.

Lunatic Asylum.³⁹ As well as being fireproof, iron sash eliminated the need for window bars. One of Mills' best known buildings is his 1822 Record Office in Charleston, popularly known as the Fireproof Building, which was built for the safekeeping of state records. It had brick walls and floors and a copper covered roof; like the State Hospital, "all sashes, frames and shutters are of iron."⁴⁰ Finally, Mills "introduced as far as was practicable the fireproof system" into the numerous county courthouses and jails he built in South Carolina in the 1820s.⁴¹ Typically, the principal story of these buildings were vaulted, but the roofs were made of wood and covered with a noncombustible material. This busy period of development ended suddenly at the end of the decade when the economic fortunes of South Carolina slumped. After appropriations for state development projects dried up, Mills moved to Washington, where he found work as a draftsman.

At this time, the federal government had no policy concerning whether its buildings should be fireproof. When in 1833 Mills received commissions to make plans for four custom houses in New England, he urged that the buildings be fireproof. The Treasury Secretary asked Mills to estimate the cost of making the four buildings fireproof or not. Mills' response provides some indication of the cost premium for building fireproof.⁴² The four buildings are similar in plan and elevation, differing mainly in exterior dimensions. Mills estimated that a solid masonry building cost invariably \$1,000 more than making the same building "in the common way," which came to 6.7 to 10.5 percent more, depending on the size of the building. Since this cost difference was inconsiderable, the government approved fireproof construction and also opted for stone rather than brick for the walls. Mills' specifications for the Middletown, Connecticut custom house called for groin arches; iron window sashes, frames and door frames; and floors paved in tile or flag stone. The

³⁹ John Foulston, The Public Buildings Erected in the West of England as Designed by John Foulston (London: J. Williams, Library of Arts, 1838), p. 70.

⁴⁰ Quoted in H. Pierce Gallagher, Robert Mills, p. 52.

⁴¹ H. Pierce Gallagher, Robert Mills, p. 161, from Mills' autobiography.

⁴² Letter from Robert Mills to Treasury Department dated Dec. 10, 1833, The Papers of Robert Mills, microfilm, roll 6.

actual cost of the buildings exceeded Mills' estimates for a granite, fireproof building by 12 to 38 percent.⁴³ Mills did not superintend the construction of the buildings, so was not responsible for the final cost. But this sort of price uncertainty must have discouraged owners from choosing the vault form of construction. These custom houses were among the very few large, solid masonry structures in New England.

Another of Latrobe's students, William Strickland (1788-1854), also became an important practitioner, and no doubt advocate, of fireproof construction. Strickland's father had been a carpenter at the Bank of Pennsylvania -- carpenters built the wood centers for the masonry vaults -- and apprenticed his son to Latrobe.⁴⁴ Strickland learned drafting in Latrobe's office and later gained construction experience superintending fortifications around Philadelphia during the War of 1812. After the war, he set up an architecture practice in Philadelphia and obtained commissions for fireproof buildings from government as well as some private clients.

In 1818, Strickland won a competition to design the Second Bank of the United States in Philadelphia, for which the bank directors wanted a "chaste imitation of Grecian architecture" that was also fireproof. Since the Bank was a private corporation, its buildings were not controlled by the government. Strickland's bank was in three sections, like Latrobe's Pennsylvania Bank. The large banking room in the center was covered with a barrel vault supported by columns -- like the banking room in the First Bank of the United States, which was located around the corner from the Second Bank and had opened two decades before. However, the First Bank, which at the time was a private bank owned by Stephen Girard, who bought it when Congress declined to renew the First Bank's charter, was not thoroughly fireproof. For secure storage, the First Bank had a vaulted ground floor and two small vaulted rooms on the first floor, used for secure storage; otherwise, the interior was

⁴³ U.S. Treasury Department, Report of the Secretary of the Treasury, 1861, figures on actual cost from Table 1, p. 113.

⁴⁴ Agnes Gilchrist, William Strickland, Architect and Engineer, 1788-1854 (Philadelphia: University of Pennsylvania Press, 1950).

made of wood.⁴⁵ The Second Bank was vaulted throughout, except for the roof, which -- no doubt to create a historically accurate pitch -- was framed in wood.⁴⁶ It was completed in 1824.

Strickland also received a commission for a rest home, the U.S. Naval Asylum in Philadelphia. This kind of building, like the state hospitals and prisons, called for greater built-in fire protection because occupants might have difficulty escaping in an emergency. Strickland described his proposed design in an 1826 letter to the Secretary of the Navy,

The Basement story will be formed of Granite. The principal and attic stories of marble:-- These stories will contain about 250 dormitories and will be arched throughout making the whole building fireproof to the roof.⁴⁷

In addition, Strickland used cast iron columns to support the balconies that lined the exterior of the building, undoubtedly as part of his plan to fireproof the building. This is one of the earliest instances of the use of cast iron columns in the U.S.

Strickland designed and superintended the construction of several other fireproof buildings for government clients in late 1820s and early 1830s: three mints for the Treasury Department and an almshouse for Blockley Township in Pennsylvania.⁴⁸ The U.S. Mint at Philadelphia had iron piazzas and staircases, and the original design for the Charlotte, North Carolina, Branch Mint called for iron piazzas,⁴⁹ such as Strickland designed for the Naval

⁴⁵ John Platt et al., Historic Structure Report, First Bank of the United States, Independence National Historical Park, Pennsylvania, Historic Preservation Division, U.S. Dept. of Interior, April 1981. The First Bank was designed in 1794 by the amateur architect and Washington real estate developer Samuel Blodget, Jr., (1757-1814) and opened for operations in 1797. It still stands, but the interior was changed considerably in the 20th century.

⁴⁶ Historic American Buildings Survey drawings measured April 5, 1939, in the collection of the Philadelphia Athenaeum. The building was sold to the Bank of Pennsylvania after Congress failed to re-authorize the bank, and then in 1844 it was sold to the federal government for use as a custom house, replacing a solid masonry custom house which Strickland designed in 1818. (Agnes Gilchrist, William Strickland, pp. 51-53.) It is still standing.

⁴⁷ Agnes Gilchrist, William Strickland, p. 73.

⁴⁸ Agnes Gilchrist, William Strickland, pp. 81 and 84.

⁴⁹ Agnes Gilchrist, William Strickland, p. 90.

Home.

Fireproof Vault Construction in New England to the Mid-1830s

Surprisingly, unlike in the Philadelphia-Baltimore area, no fireproof construction tradition developed in the populous New England and New York regions. The comparatively large number of fireproof buildings in Philadelphia, of course, was due to the activity of Latrobe, Mills, and Strickland, each of whom lived in that city. Philadelphia clients presumably had an opportunity to see the vault buildings and this familiarity may have encouraged some them to opt for fireproof construction. By the same token, the absence of vault buildings in New York and New England, and hence lack of acquaintance with the system, may have discouraged owners in these areas from adopting it. The local acceptance of vault construction made it possible for an emigrant British architect, John Haviland, who settled in Philadelphia around 1816, to receive a number of commissions for fireproof buildings in Philadelphia. By contrast, the British architects who emigrated to Boston and New York received no such commissions. The few fireproof or partly vaulted buildings constructed in New England before the early 1830s were designed by American-born architects who were not from Philadelphia or connected with Latrobe.

In Boston, several partly fireproof buildings were designed and built by native New Englanders for the usual sorts of clients, government and institutions. Perhaps the first such building was the U.S. Custom House (c. 1810). The design is attributed to Uriah Cotting, about whom little is known save that he was active in real estate development.⁵⁰ The building was described in an 1828 history of Boston as being two stories with a basement "divided by brick walls and brick arches supporting the different passages above.... The floor is paved with stone, and a broad flight of stone steps with iron railings leads to the several offices."⁵¹ These features undoubtedly were designed for fire safety. It is impossible to say where Cotting, whose design career is obscure, got his ideas. Latrobe's 1807 custom house

⁵⁰ Cotting was among the projectors of the New Cornhill Corporation, chartered 1815, which developed land near Faneuil Hall Market and the Boston and Roxbury Mill Corporation, chartered 1814. According to an early history of Boston, Cotting died before 1821 (Caleb Snow, 2nd edition History of Boston, p. 320.)

⁵¹ Caleb Snow, 2nd edition History of Boston, p. 329.

for New Orleans, which also had fireproof vaults over the lower floor, may have served as the model, although the facades of the two buildings are dissimilar, except that both have columned porches and classical details.

The next partly vaulted Boston building was Massachusetts General Hospital, designed in 1818 by Charles Bulfinch (1763-1844). Sections of the cellar and basement levels, and also the corridors on the principal level, were vaulted; otherwise, the internal structure was made of wood. The stairs and flooring of the main entryway are, like the Custom House, made of stone. Whether Bulfinch designed the vaults and the stone floors or they were introduced by Alexander Parris (1780-1852), who superintended the construction of the building, is uncertain. Bulfinch left Boston for Washington to be architect for the U.S. Capitol before construction on the hospital began, and none of his drawings have survived. However, Bulfinch was not experimental in matters of building construction while Parris -- who had a background in the building trades, had served in the Corps of Artificers in the War of 1812 and left with the rank of captain, and was trying to establish an architectural practice in Boston -- was. The hospital was not called fireproof by contemporaries and indeed it was not, although the stone staircase and entryway were unusual enough to rate a description in an 1838 guidebook.⁵² The stone used in this building was cut by prisoners at the state prison in Charlestown, Massachusetts.⁵³ Convict labor made possible the great increase in the use of building stone in Boston, and elsewhere in the nation, in the early nineteenth century.⁵⁴

The only large building designed by a New England architect in this period that might

⁵² Bowen's Picture of Boston 3rd edition (Boston: Otis, Broaders & Co., 1838).

⁵³ Massachusetts General Hospital, Memorial and Historical Volume, 1921.

⁵⁴ Stone cutting was one of the occupations for prisoners at the Walnut Street Jail, Philadelphia. Prisoners at Sing Sing dressed the stone used in the Connecticut State Capitol (1827-31), New York University, and New York Custom House; and Ohio prisoners did likewise for Ohio's State Capitol (Roger Newton, Town & Davis, Architects (New York: Columbia University Press, 1942), p. 158 and 163.) Convicts at New Hampshire's state prison in Concord worked stone that was shipped around the country, including to Boston. (Donna-Belle Garvin, "The Granite Quarries of Rattlesnake Hill," Industrial Archeology vol. 20 (1994), p. 51.) In the South, the stone for South Carolina's state house, constructed in the 1850s, was quarried by slaves.

have been thoroughly vaulted was the U.S. Branch Bank in Boston, but so little information remains about how it was built that it is impossible to know. Construction began on the bank in 1824, shortly after Parris completed the Massachusetts General Hospital with its vaulted cellar. It was designed by Solomon Willard (1783-1861) and, probably to satisfy Grecophile bank president Nicholas Biddle's taste, had a front portico with two huge, granite columns with Doric capitals. Its plan was similar to Latrobe's Bank of Pennsylvania: a rectangle with two small rooms at the ends and a central, circular banking room, thirty-six feet in diameter, covered with a dome. A contemporary description of the building mentions that it was built with "refractory material (Chelmsford granite)," but does not say that the building was fireproof.⁵⁵

Willard designed another granite temple in 1833, for a new court house for Suffolk County in Boston. Parris worked on this building in some capacity, as he says he constructed some room with vaults "of a spheroidal form," and used this same arch for the fireproof *gunpowder magazine* he built a few years later at the Chelsea, Massachusetts Navy Yard.⁵⁶ But the court house was not known as a fireproof building, so it must not have been thoroughly vaulted.

The only certain solid masonry fireproof buildings in New England designed by a local architect, up until the year 1837, were two gunpowder magazines. Magazines were buildings for storing gunpowder, to keep it out of houses and other buildings where it could accidentally be ignited and explode. The first of these magazines was built in 1817 at the

⁵⁵ Caleb Snow, 3rd edition History of Boston, p. 375.

⁵⁶ U.S. House of Representatives, Report No. 737, 1838, p. 33. Other evidence that Parris worked on this building is found in an 1878 memorial of Richard Upjohn, which states that Upjohn moved to Boston in 1833 and became an assistant to Parris, "then architect of the Boston Court House." (American Institute of Architects, minutes of the Board of Trustees, 1878.) In addition to Parris and Willard, James McAllister worked on this building. He was a master carpenter and is listed as Superintendent of the New Court House, Boston, in an advertisement in James Gallier's American Builder's General Price Book and Estimator (Boston: M. Burns, 1836).

U.S. Army's new arsenal at Watertown, Massachusetts, probably from designs by Parris.⁵⁷ Parris, who became acquainted with military facilities during the recent war, was employed to design buildings for the arsenal complex. The gunpowder magazine was a one story rectangle, about eighty by thirty-two feet, with stone walls and "a range of pillars in the center supporting Groin arches of 12 feet space," according to Capt. George Talcott, the arsenal's commanding officer.⁵⁸ It was a very expensive building, costing about \$25,000, but the danger of explosion undoubtedly justified such a substantial structure. Just the year before it was built, at least five men were killed at the arsenal in an explosion, possibly of black powder.⁵⁹

Gunpowder magazines had long been constructed with brick walls and vaulted roofs. A very small rectangular one in South Carolina probably dating from the 18th century shows that this system of construction was brought from England.⁶⁰ Larger, vaulted gunpowder magazines, more like the Watertown building, were built for the British Board of Ordnance at navy yards. At the Morice Yard in Devonport, magazines of rectangular shape covered with vaults date from the 1740s.⁶¹ A notable feature of these buildings were the double brick walls with an insulating air space in between. The walls of the Watertown magazine, on the other hand, were solid stone.

The circular gunpowder magazine built for the Navy in the 1830s at Chelsea, Mass., mentioned above, was designed by Parris. There were precedents for this building as well.

⁵⁷ The date of 1817 for the magazine is supported by the fact that in March 1818, 224,000 pounds of saltpetre and the next month 50,903 pounds of sulfur -- the main ingredients of black powder -- were received at the arsenal. (Judy Dobbs, A History of the Watertown Arsenal, Watertown, Mass., 1816-1967, Army Materials and Mechanics Research Center, 1977, p. 17.) These materials presumably would not have been received if the magazine was not ready to hold them.

⁵⁸ Judy Dobbs, Watertown Arsenal, p. 10.

⁵⁹ Judy Dobbs, Watertown Arsenal, p. 5.

⁶⁰ Historic American Engineering Record, "'Dead House' Documentation," no date. The building is on the grounds of the Charleston, S. C., Naval Base.

⁶¹ Jonathan Coad, The Royal Dockyards 1690-1850 (Aldershot: Scolar Press, 1989), pp. 254-55.

Latrobe designed a "circular, masonry-vaulted building with a conical roof" for the U.S. government in 1798, and a building like this was constructed in Washington during the War of 1812.⁶² He also designed a gunpowder magazine and a vaulted arsenal building for the U.S. Arsenal at Pittsburgh in 1814.⁶³ (Illustration 2-5.) In 1817, Robert Mills urged that Baltimore's magazine, dangerously located in the center of the city, be removed and offered several designs for a new magazine.⁶⁴ One of the designs is for a rectangular building with a range of columns in the center and segmental arches, perhaps like the Watertown magazine except that Mills' building has two stories. Another design was for a circular magazine, probably modeled on Latrobe's magazines, which was covered with a pointed arch rather than a spherical dome. Mills' plan for a cluster of circular, remotely located gunpowder magazines was eventually implemented in the 1820s in Charleston, South Carolina.⁶⁵ Closer to home, Capt. Talcott had first proposed an octagonal shaped magazine for Watertown, with a twenty-two foot brick arch over the interior and a conical roof, but this proposal was turned down by his superiors.

Considering that New England had many cities with large populations and thriving commerce and industry, it is surprising that no banks, prisons, markets, and few federal government buildings, were built thoroughly fireproof. Parris' best known project -- the blocks of stores and the domed market building behind Faneuil Hall, designed in 1824 -- was not fireproof, nor were most of the buildings he designed for the Charlestown, Massachusetts, Navy Yard (the exceptions are discussed in the next chapter). Even the Tremont House,

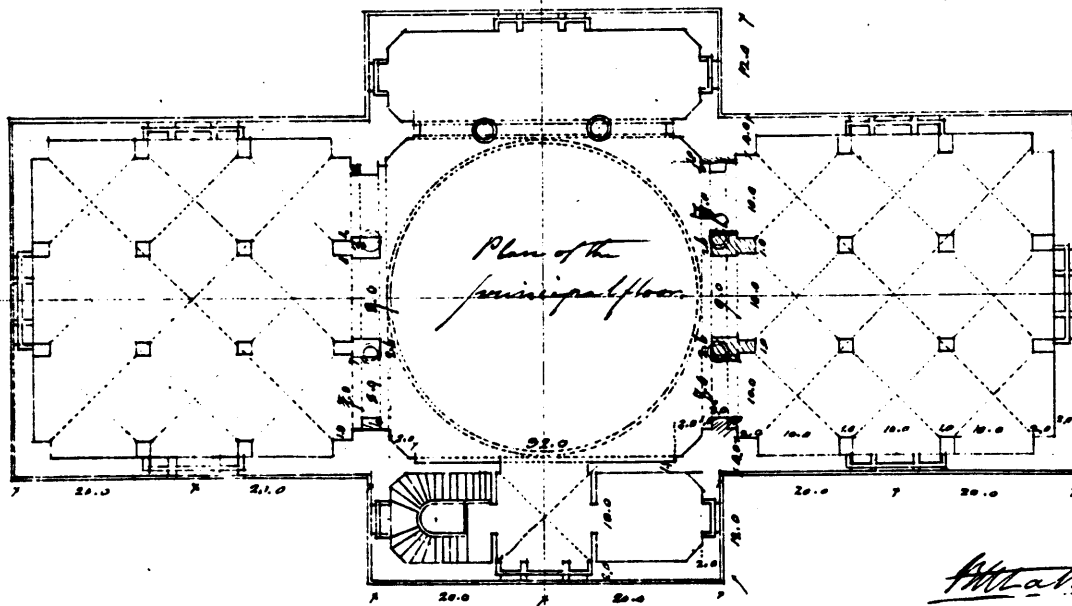
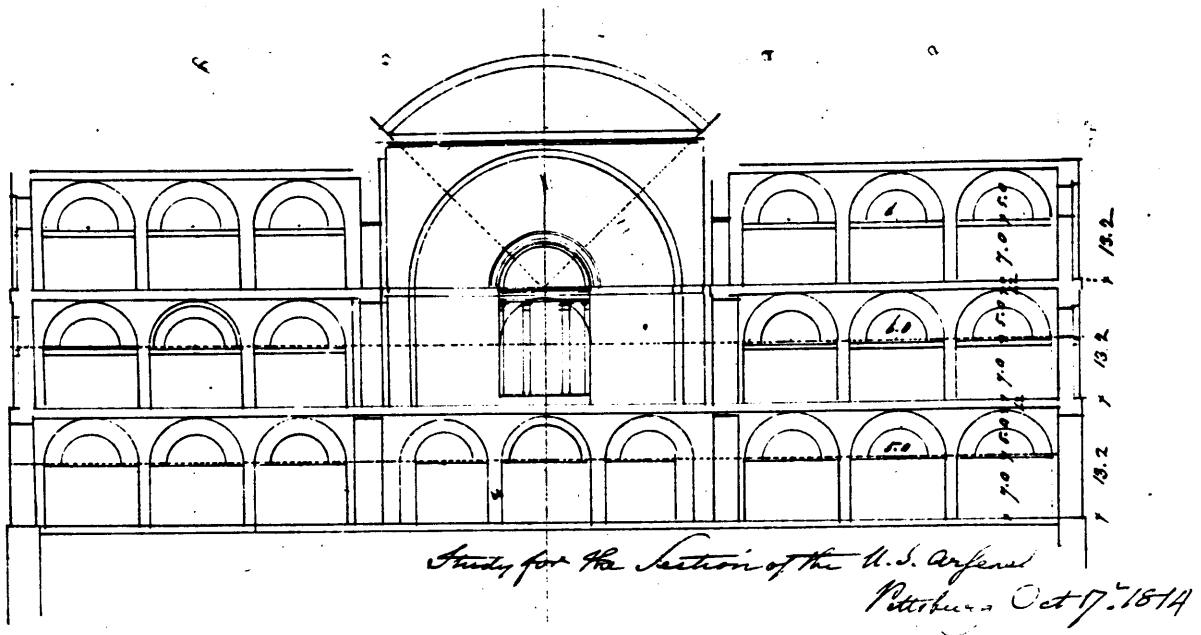
⁶² Talbot Hamlin, Latrobe, p. 255. I have been unable to find out more about these buildings.

⁶³ Talbot Hamlin, Latrobe, pp. 419-422.

⁶⁴ The Peale Museum, "Proposed Powder Magazine by Robert Mills, 1817." Copy of the drawing provided by Mary Markey, Reference Center Supervisor. Robert Mills to Mayor and City Council of Baltimore, October 12, 1817, Papers of Robert Mills, microfilm, roll 4. The drawing is also in the Papers of Robert Mills microfilm collection.

⁶⁵ The Papers of Robert Mills, microfilm, copy of Historic American Buildings Survey drawing, "State Powder Magazines," Charleston, South Carolina. The rationale for building several small magazines rather than one large one was to minimize the destructiveness of an explosion. Mills argued that this arrangement was the practice in Europe.

Illustration 2-5. Latrobe's design for an arsenal building for Pittsburgh (1814).



considered the prototype of the modern hotel in the U.S. and one of the most renowned Boston buildings of its day (the 1820s), contained many fire safety provisions but was not thoroughly fireproof.⁶⁶

Local tradesmen had little opportunity to become proficient at constructing vaults. Vault buildings took much longer to complete than ordinary ones. The cost of the partly vaulted buildings that were built in New England often exceeded estimates. For example, Parris built an impressive vaulted cellar under the portico of St. Paul's Church, 1819-20, which included two fireproof storage rooms under the staircase.⁶⁷ The building cost about a third more than the estimate, in part because of the cost of the cellar and foundation, and the exterior was never finished as planned for lack of funds.⁶⁸ Considering these drawbacks, owners may have shied away from these novel and unpredictable methods.

Since New England architects, too, had few commissions for vault buildings and few opportunities to learn first hand, how did they learn to design them? They must have applied construction ideas they read about or observed. It is well known that architects used books for design ideas. That many also applied construction techniques they learned about from books may seem surprising. It is common today to assume that technique was diffused by people, from more experienced artisans to the less experienced.⁶⁹ In the case of the building industry, however, it seems that many artisans and designers learned technique from books. Many of the novel construction techniques used in New England, by men born in New England, were adaptations of techniques described in builder's textbooks, particularly British books. The designers who were inclined to experiment with new construction methods had

⁶⁶ These included laying plaster directly on the walls of the kitchen, without furring; putting mortar firestops in the cavity between the exterior and interior walls; and putting a layer of mortar on the floors to prevent them from being burned through. (A Description of the Tremont House with Architectural Illustrations (Boston: Gray and Bowen, 1830.)

⁶⁷ This cellar is still pretty intact. The iron doors to the two rooms are gone but the hinges and iron frames remain.

⁶⁸ Edward Zimmer, The Architectural Career of Alexander Parris (1780-1852), PhD dissertation, Boston University, 1984, p. 388.

⁶⁹ David Jeremy, Transatlantic Industrial Revolution: The Diffusion of Textile Technologies between Britain and America, 1790-1830s (Cambridge: M.I.T. Press, 1981).

two characteristics in common: they had backgrounds in the building trades and they had access to books. They had libraries of their own, and they joined trade, scientific, and social organizations that had libraries.

The careers of Parris and Willard, and another New England architect, Ithiel Town (1784-1844), illustrate the proposition that books were an important means for technological advance and diffusion in the construction field. Both Parris and Willard were experienced builders and self-taught designers. Parris had apprenticed as a carpenter and worked as a builder and designer before the War of 1812.⁷⁰ Willard worked as a housewright, carver, and architectural model maker. He carved the wooden spread eagle that topped Boston's 1810 Custom House and so would have known the vaulting used in this building. Both men had seen Latrobe's vaults at the U.S. Capitol, Parris in 1812, when he was taken on a tour by Latrobe, and Willard in 1810 and 1818. Willard also worked in Baltimore 1817-18 and had met Robert Mills, who had recently completed his monument to Washington in that city.⁷¹ Both, therefore, had much practical experience and had seen vault buildings. But in addition, they joined the Architectural Library in Boston, the Athenaeum, and the Boston Mechanics' Institution, where they had access to architectural and technical books.⁷² Parris amassed a large library of engineering and architectural books.⁷³ Willard's biographer writes that as a youth, Willard bought tools and books. His description of Willard captures the engineering orientation,

He [Willard] was one who always worked with his head as well as hands, and in doing a piece of work himself, or seeing another do it, his immediate thought would

⁷⁰ Edward Zimmer, Alexander Parris. Unless otherwise cited, this is my main source of information on Parris.

⁷¹ William Wheildon, Memoir of Solomon Willard, The Monument Association (1865), p. 36.

⁷² Christopher Monkhouse, "Parris' Perusal," Old-Time New England vol. 58 (Fall, 1967).

⁷³ Some of Parris' books are mentioned in Christopher Monkhouse, "Parris' Perusal." Parris gave left his engineering books to a relative, Benjamin F. Chandler; the collection included many English technical books. (Chandler to Chandler, City of Portsmouth, New Hampshire, personal property mortgages, 1853.) Thanks to Richard Candee for these references.

be whether it could not be done in some easier, quicker or cheaper way, or in a more perfect manner.⁷⁴

Ithiel Town was born in Connecticut, learned the carpenter trade in the Boston area, and became an architect and builder. In addition to designing several fireproof buildings, he also patented a bridge truss that was widely used and made him a wealthy man. He acquired one of the largest private libraries in the U.S. in his day, which included many architectural books.⁷⁵ The careers of these men show that it was possible for Americans, even without specific training in novel construction methods, to execute them nevertheless, with guidance from English architectural writers combined with practical experience in construction.⁷⁶

The second generation of structurally experimental New Englanders did get some direct training. Isaiah Rogers (1800-1869), who had apprenticed as a housewright as a youth, worked with Willard in the 1820s and then set up his own design practice, although he remained a friend and occasionally business partner of Willard's. In the first half of the 1830s, Gridley James Fox Bryant (1816-1899) worked with Parris while Parris was architect and engineer at the Boston Navy Yard, and went on to design fireproof buildings in Boston and elsewhere, beginning in the 1850s.⁷⁷ Bryant's father, Gridley Bryant (1789-1867), was the master mason on Willard's U.S. Branch Bank as well as Parris' Suffolk County Jail and Court House (1820-22), and later became famous as an engineer and inventor. The elder

⁷⁴ William Wheildon, Solomon Willard, p. 27.

⁷⁵ George Dudley Seymour, "Ithiel Town -- Architect," Art and Progress vol. 3 (September, 1912), pp. 714-716, and George D. Seymour, "Ithiel Town: Architect: Bridge-Builder 1784-1844," New Haven (New Haven: privately printed for the Author, 1942).

⁷⁶ Edward Zimmer concludes that Parris got his ideas for innovative construction methods from "English books and observations of innovative buildings," and I agree with him. (Alexander Parris, p. 491.) However, he suggests that these methods were required because of "the special challenges" of the Parris' commissions. It seems to me that the architectural effects of Parris' buildings could have been achieved with ordinary construction methods. Rather, I suspect that Parris persuaded his conservative clients to accept novel techniques. But New England building owners must have been reluctant to embrace new methods, since no regional fireproof construction tradition developed as in the Philadelphia area.

⁷⁷ Henry T. Bailey, "An Architect of the Old School," New England Magazine ns vol. 31 (November, 1901-02), pp. 326-349.

Bryant conceived and built a horse-drawn railroad to transport the stone for the Bunker Hill Monument from a quarry in Quincy to tide-water for shipping. He recalled that he got the idea of the railroad from reading about plans for the Manchester and Liverpool Railroad in England -- another example of an idea from a printed source being translated into a real project.⁷⁸

The Federal Government Adopts Fireproof Construction

In the 1830s, the federal government changed its policy toward its buildings: it began to build more buildings, and it began to make them fireproof. In so doing, it became an important patron and disseminator of fireproof construction, a role it would have throughout the century. Up to the 1830s, even in Washington, the government generally met its space requirements by purchasing and modifying existing buildings rather than building new ones. The General Post Office and Patent Office in Washington, for example, shared a building known as "Blodget's Hotel." As a rule, these old buildings were not fireproof, but the new buildings the government built increasingly were.

The contrast between the new buildings and the old ones only called attention to the vulnerability of the latter and, therefore, how at risk government property was. When Washington was torched in the War of 1812, only the records and models of the Patent Office had been spared by the British, in the interest of science. Despite this warning, the government was in no haste to find more secure homes for federal offices and records. Then the Treasury Department was set afire for a second time, by an arsonist in 1833 and, with the exception of Latrobe's fireproof wing, was destroyed. At last, Congress authorized the President to replace the Treasury with a "fire-proof building."⁷⁹ Meanwhile, the chairman of the House Committee on Patents, concerned that the Patent Office could suffer the same fate as the Treasury, introduced a bill which provided "for erecting a fire-proof building for the

⁷⁸ Charles F. Adams, "The Canal and Railroad Enterprise of Boston," in Justin Winsor, The Memorial History of Boston vol. 4 (Boston: James R. Osgood & Co., 1881-83), pp. 116-120.

⁷⁹ "Speech of Mr. (Levi) Lincoln, of Massachusetts, on the Removal of the Treasury Building," delivered in the U.S. House of Representatives, April 17, 1838 (Washington, 1838), p. 3.

Patent Office."⁸⁰ The bill died and tragically, Blodget's Hotel did indeed burn down, on December 15, 1836, and with it all of the Patent Office's records and models.⁸¹ Again, the legislation for funding new buildings for the Post Office and Patent Office specified that they be fireproof.

Because of squabbles over where to locate the new Treasury building, construction did not commence until 1836, when President Jackson appointed Robert Mills architect for the Treasury building. Mills also was appointed superintending architect for the Patent Office, which got underway soon after the Treasury building.⁸² In 1839, he prepared designs for the new Post Office and was appointed to superintend its construction as well. The interiors of all three were vaulted, in Mills' characteristic style. Also, characteristically, all had wooden roofs.⁸³

Fireproof construction was becoming standard for federal civil buildings outside of Washington, as well. In 1833, Mills had had to convince the Treasury Secretary to build his four New England custom houses fireproof. Thereafter fireproof construction was standard for federal buildings in large cities. Examples include the new New York Custom House, new Boston Custom House, the U.S. Mint in New Orleans, and a public storehouse (U.S. Appraisers Stores) in Baltimore. In many areas of the nation, the federal buildings were important because they often were the only examples of fireproof construction. The military also began to build more of the buildings on its bases fireproof.

The fireproof custom houses in New York and Boston were among the most costly buildings in the U.S. when they were built. A number of designers worked on the New York

⁸⁰ Jane Davies, "A. J. Davis' Projects for a Patent Office Building, 1832-34," Journal of the Society of Architectural Historians vol. 24 (October, 1965), pp. 229-251.

⁸¹ Constance Green, Washington, A History of the Capital 1800-1950 (Princeton: Princeton University Press, 1976), first published 1962.

⁸² William P. Elliot, with Ithiel Town, are credited with the design of the facade of this building. (National Collection of Fine Arts, National Portrait Gallery (Washington, D.C.), p. 6.)

⁸³ Account of the report of the Commission appointed to investigate the security of public buildings following the Patent Office fire in 1877, AABN vol. 3 (Jan. 5, 1878), p. 1.

Custom House (1833-1841), but the exterior is usually attributed to Ithiel Town and Alexander Davis. This building is Greek, with a monumental Doric style porch and the now conventional central rotunda topped with a dome -- a necessary by-product of using stone and brick exclusively in the construction. (Illustration 2-6.) As an architect described the building at the end of the nineteenth century,

Not only are the floors and ceilings of masonry, but the roof besides is entirely of marble, supported on the groined arches and the dome of the rotunda is of masonry vaulted construction. The interior is also principally of marble and the whole building is invulnerable to fire and enduring as the ages.⁸⁴

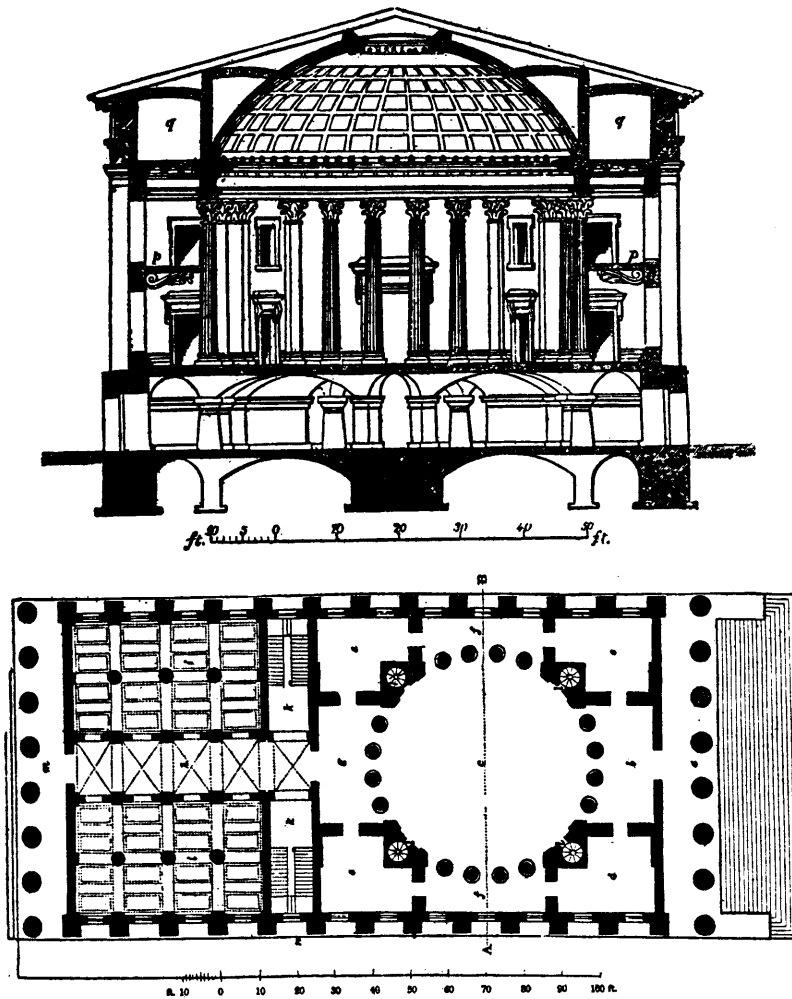
Not to be outdone by New York, Boston merchants lobbied successfully for a new custom house and construction began on Boston's equally monumental custom house a few years later. Designed by Ammi Burnham Young (1798-1874), this massive, vaulted structure took even longer than New York's to build -- over ten years (1837-1849). Young had apprenticed in the construction trades as a youth and had superintended the construction of Vermont's granite, although not fireproof, Statehouse in Montpelier (completed 1838). Boston's custom house, like New York's, was built entirely of masonry, had a central rotunda, and a dome.

Government buildings invariably were criticized for being too costly, but the charge was justified in the cases of these two custom houses. Criticizing the Boston custom house, the architect Arthur Gilman wrote in 1844 that it contained enough material for at least three buildings of the same size and that despite the government's "reckless squandering," so much of the interior space was wasted in the thick walls and piers that the building "will never afford the requisite accommodation for the revenue offices in a large and rapidly growing metropolis."⁸⁵

⁸⁴ Richard M. Upjohn, AABN vol. 38 (Nov. 5, 1892), p. 80. While Town and Davis were first selected as architects for the building, Davis told Upjohn that William Ross "designed the building as built." John Frazee, to whom the building also has been attributed, was the construction superintendent. This building, now Federal Hall National Memorial, still stands at the corner of Wall and Nassau Streets.

⁸⁵ Arthur Gilman, "Architecture in the United States," North American Review vol. 58 (April, 1844), p. 444.

Illustration 2-6. New York Customs House, section and plan.



Gilman was wrong about the longevity of this building, which continued to be used for customs purposes until the second decade of the twentieth century, at which point the interior was gutted. (The old custom house now forms the base of the custom house tower.) New York outgrew Town and Davis' custom house much sooner, in the 1850s, and the building was converted to a U.S. Sub-treasury in 1862.

Heyday of Vault Construction - the 1830s

Private owners, too, began to build fireproof buildings to a greater extent in the 1830s. One of the most prominent -- and, at nearly \$2 million, most expensive -- was Girard College in Philadelphia. Girard College was a secondary school for orphan children, established with funds from the estate of Philadelphia merchant and philanthropist, Stephen Girard. Girard's

will stipulated that the main building (Founder's Hall) should be substantial, "avoiding needless ornament," and "It shall be fire-proof inside and outside. The floors and roof to be formed of solid materials, on arches turned on proper centres, so that no wood may be used, except for doors, windows, and shutters...."⁸⁶ Rather than the plain school for orphans Girard had in mind, or even the plan that was selected by the city officials who administered Girard's estate, the chairman of the Board of Trustees, Nicholas Biddle, decided that a peristyle temple would be a more suitable structure and ordered the winner of the architectural competition, Thomas Ustick Walter (1804-1887), to design one. The cost of the building, and the amount of time it took to complete -- fifteen years -- attracted much criticism and left Walter open to the charge of being extravagant. Walter was the son of a mason and he learned the trade himself as well as architectural design as an apprentice in Strickland's office, carrying on the tradition of Latrobe. He received many commissions for masonry fireproof buildings.

Three fireproof, or partly fireproof, Merchant Exchanges were built in the 1830s and early 1840s, in Boston, New York, and Philadelphia. These Exchanges were built by groups of investors and contained offices, dining rooms, sometimes a hotel and library, as well as a large exchange room. An early example of this type of building was the Boston Exchange Coffee House on Devonshire Street, built 1805-1808. It was remarkable for its large size, being seven stories high, and though it had been "ruinously expensive" to build, its interior was made of wood. The building was totally destroyed in a dramatic fire in 1818,⁸⁷ in which Solomon Willard's spiral staircase extending from the basement to the roof probably served as a flue. Nevertheless, the Exchange Coffee House that replaced it in 1822⁸⁸ was not fireproof. The city of Baltimore had a partly fireproof Exchange, designed by Latrobe with Maximilien Godefroy (1765-1840?) in 1816, with a central hall covered with a brick

⁸⁶ Will of Stephen Girard, quoted in Bruce Laverty, "Girard College Architectural Collections," The Athenaeum of Philadelphia, 1994.

⁸⁷ Caleb Snow, 2nd edition History of Boston, pp. 329-331.

⁸⁸ Dane Yorke, Able Men of Boston (Boston: Boston Manufacturers Mutual Fire Insurance Company, 1950), pp. 87-89. Nor was the City Exchange Building, built on the site of the Coffee House after it was torn down in 1854, fireproof.

dome and a vaulted basement used for offices and store rooms.⁸⁹

The Exchange buildings of the 1830s were similar to the Baltimore building. In Philadelphia, a Merchant's Exchange with a vaulted ground floor was built between 1832-34 from designs by William Strickland. The halls were flagged with marble, and brick partition walls divided the rooms; wooden floor boards were laid on mortar⁹⁰ -- a measure which muffled sound and also created a fire barrier. New York's second (1827) Merchant Exchange on Wall Street, a "splendid edifice"⁹¹ designed by Ithiel Town, but apparently not a masonry vaulted building like his New York Custom House, then under construction, burned down in the great fire in lower Manhattan in 1835. The local businessmen resolved that in the new building, "every room shall be vaulted and rest upon arches, and be made completely fire proof."⁹² It was replaced (1836-42) with an even more lavish, partly vaulted, building.

The architect of the third Exchange, Isaiah Rogers -- like Town, originally from New England -- was in New York working on the Astor Hotel at the time of the fire, a commission he got on the strength of his much admired Tremont House in Boston. According to the diarist Philip Hone, who invested in the project, the Exchange cost nearly \$2 million, and Hone doubted that it would generate sufficient revenue to repay the debt.⁹³ As work on the New York Exchange was nearing completion, Rogers was commissioned to design a Merchant's Exchange for Boston, which was built around the corner from the

⁸⁹ Talbot Hamlin, Latrobe, p. 493.

⁹⁰ Agnes Gilchrist, William Strickland, p. 86.

⁹¹ So described by Philip Hone in his diary, December 17, 1835. The destruction of the Exchange impressed Hone, who wrote, "When the dome of this edifice fell in, the sight was awfully grand. In its fall it demolished the statue of Hamilton executed by Ball Hughes, which was erected in the rotunda only eight months ago...." It opened May 1, 1827.

⁹² I. N. Phelps Stokes, Iconography of Manhattan Island, 1498-1909 vol. 5 (New York: Arno Press, 1967), Jan. 18, 1836.

⁹³ It was converted into the city's custom house during the Civil War and the old custom house became the U.S. Sub-treasury for New York. Part of this building exists today. Citibank bought the building when the federal government built a new custom house and in about 1907 remodeled it for bank offices. Solomon Willard, Rogers' friend and colleague, supply the granite for the building from a Quincy, Mass., quarry. (W. Wheildon, Solomon Willard, p. 233.)

Exchange Coffee house in 1840-42. According to an 1860 Boston guidebook, the "entire building is fire-proof," with staircases of iron and stone.⁹⁴

Limitations of the Solid Masonry Building and Some Alternatives

Why did the masonry vault type building alone come to define what was meant by a "fireproof building?" The answer is probably that the architects who designed this sort of building established the definition and taught the public that this was what a fireproof building was. Anyone who read Robert Mills' Washington guidebook, Guide to the Executive Offices and the Capitol of the United States, learned that the vaulted Treasury, Patent, and Post Office buildings were "fire-proof."

In one important respect, the vault buildings functioned extremely well: they were indeed fireproof, as their performance in actual fires demonstrated. Latrobe's south wing of the Capitol survived after the building was burned by the British in 1814⁹⁵ and his 1805-06 fireproof wing on the Treasury building was little injured in the 1833 fire.⁹⁶ An 1877 fire in the Patent Office badly damaged sections of the building but not Mills' vaulted south wing.⁹⁷ Despite this, the south wing was considerably rebuilt when the building was repaired, according to the ideas of best practice in the 1880s, and little remains of the original structure today. Finally, Mills' federal warehouse survived the 1904 Baltimore conflagration,⁹⁸ only to fall to a wrecking ball in 1933.

⁹⁴ Sketches and Business Directory of Boston and Its Vicinity for 1860 and 1861 (Boston: Damrell & Moore & Geo. Coolidge, 1860).

⁹⁵ John Latrobe, "The Capitol and Washington at the Beginning of the Present Century, An Address ... Before the American Institute of Architects in Washington, D.C.," Nov. 16, 1881, p. 14.

⁹⁶ Mills to Secretary of the Treasury [Louis McLane], April 6, 1833 (RM microfilm, roll 6). Mills was asked to plan repairs for the building after the fire, and he reported that the "fireproof wing received little or no injury from the fire, but the main building...suffered total demolition."

⁹⁷ New York Times, Sept. 25 and 26, 1877.

⁹⁸ "Detailed Studies of Fireproof Buildings in the Baltimore Conflagration," Engineering News vol. 51 (February 25, 1904), pp. 169-173. Mills' "Fireproof" Building in Charleston was outside the paths of two conflagrations in that city, in 1838 and 1861, however it did survive an earthquake in 1886.

However, as containers for human life and work, the vault structures were much less successful. Their problems stemmed from the unsuitability of a monumental system of construction for buildings intended for ordinary purposes. To bear the weight and thrust of the arches, the buildings had to have massive walls, so thick they obstructed light from the windows; the acoustics in what were essentially caves were often very bad. These problems doomed some of the vault buildings, like Girard College, to failure from the start. Probably none of them, with the exception of the gunpowder magazines, could be considered well adapted to the purposes for which they were built, and they came in for heavy criticism. The central corridor in Mills' Treasury Department building, complained the chairman of the House Committee on Public Buildings and Grounds, "more nearly resembl(ed) the tunnel of a railroad than ... a building."⁹⁹ Abram Hewitt, the prominent iron master and Democratic politician, wrote in 1855, "In all these (masonry fireproof) ... buildings, the basement story is rendered dark, and gloomy and dungeon-like by the immense number and massive forms of the walls, piers, columns, and groined and vaulted arches...."¹⁰⁰ This judgment was echoed by a late nineteenth century writer who faulted the system for its "oppressive solidity, its obtrusive monotony of interior effect, its extravagant occupancy of space and headroom, and voluminous masses of dead material."¹⁰¹

The great amount and weight of the material of construction made the buildings especially vulnerable to the destructive force of gravity. They were so heavy that when they were built on compressible soil they settled. Uneven settlement of Latrobe's custom house at New Orleans, previously discussed, cracked the walls and ruined the building. The walls of custom house at Newburyport had to be tied with an iron rod to prevent them from bulging out.¹⁰²

⁹⁹ "Speech of Mr. (Levi) Lincoln...on the Removal of the Treasury Building," April 17, 1838, p. 5. The corridor was open at both ends when he made his comments.

¹⁰⁰ Jacob Abbot, The Harper Establishment (Hamden, Conn.: The Shoestring Press, 1956) reprint of 1855, p. 25.

¹⁰¹ Edwin Betolett, "Fireproof Construction in Philadelphia."

¹⁰² Betsy Woodman, A Customhouse for Newburyport (1834-1835) (privately printed, 1985), p. 5.

Not only was the final product not a happy one, but the technical problems associated with building them often increased their cost and delayed their completion. According to Mills, the great masonry spans of Latrobe's Philadelphia Bank had been difficult to construct, although he does not say whether the reason was owing to a complicated design or workers who lacked the necessary skill to execute it. Outside the Philadelphia area, Mills certainly did have trouble finding knowledgeable masons. He wrote that his court houses and jails in South Carolina were built "by mechanics who were little acquainted with the construction of groin-arches or centering," and that in New England, "I found not a single bricklayer that knew how to turn a groin.... I had to instruct the workmen, both in forming the centres and cutting the groin...."¹⁰³ John Niernsee, architect of the South Carolina Capitol in Columbia in the 1850s, could not find masons in the state capable of building the intersecting vaults in the main corridor and had to set up a school to train workers, who then executed the work.¹⁰⁴ In addition, according to Mills, it was because contractors were unfamiliar with the system that their bids for the Middletown, Connecticut, custom house were so much higher than his estimate. He explained the difference thus, "the thorough manner here proposed of giving a Fire proof character to our building is new among our Mechanics, and hence may account for the heavy valuation put by them upon such work...."¹⁰⁵ The vault buildings often took an extraordinarily long time to build. The New York Merchant Exchange was under construction for five years, Boston Custom House took more than ten, and Girard College, about fifteen years. Businesses could not have kept money tied up for such periods of time.

Mills seems to have been the only one of the vault architects who tried to improve the system. For example, in the Treasury building in Washington, he tried to reduce the thickness of the walls by using cement rather than mortar to make the arches, which he

¹⁰³ U.S. House of Representatives, Report No. 737, p. 23. Of course, there were some partly vaulted buildings in New England, but so few that workman undoubtedly would have had little experience with the system.

¹⁰⁴ AABN vol. 38 (October 29, 1892), p. 69.

¹⁰⁵ Mills to Secretary of the Treasury William Duane, August 14, 1833, in Papers of Robert Mills, microfilm.

believed would reduce the thrust of the arch. Yet he was taken to task for his innovations by the House Committee on Public Buildings and Grounds, which questioned whether his buildings were sound and he was competent.¹⁰⁶ The committee hired Walter and also Parris to evaluate the sufficiency of the walls; both men gave adverse reports, recommending that the walls be strengthened or the system of construction changed. This investigation was motivated by politics, presumably aimed at embarrassing President Jackson and his followers. In his defense, Mills tried to show that he had used the system successfully in the past, stating that his State Hospital in Columbia, with walls but 2 1/2 bricks thick, exclusive of piers, was still intact. He kept his job and his buildings in Washington, despite dire predictions, are still standing.¹⁰⁷ But he was alone in attempting such innovations.

These drawbacks stimulated a search for more practical and affordable alternatives -- to build in greater security by other means. Rather than eliminating the building itself as a source of fuel -- an objective in a fireproof building -- the parts of a building were separated by barriers, a strategy one fireproof building expert later in the century called the "compartment system."¹⁰⁸ Of course, the idea of erecting barriers between buildings, for the purpose of checking the spread of fire, was an old one; it was the reason communities required substantial masonry walls between attached buildings. As applied inside a building, the idea was to create barriers that would prevent fire from burning through a floor and spreading laterally to engulf a large area of a building. Thus, floorboards sometimes were protected with a noncombustible barrier.

The most common barrier was a layer of mortar spread on the under-floor, which was

¹⁰⁶ U.S. House of Representatives, Report No. 737.

¹⁰⁷ That it is still standing in 1994 is obvious enough. In 1853 a former Congressman and friend of Mills, R. W. Thompson, wrote to the President commending Mills' design work, noting that the Treasury building had held up perfectly, contrary to warnings from Walter, who was then remodeling the Capitol. (RM microfilm.) Not all of Mills' buildings have proven as sturdy. The walls of his custom house at Newburyport bulged and had to be restrained with iron tie bars across its length, although Mills did not superintend the construction of this building. (Betsy Woodman, A Customhouse for Newburyport.)

¹⁰⁸ Peter Wight, "On the Relation of Architecture to Underwriting," AABN vol. 5 (May 31, 1879), p. 171.

covered with the finish floor. Mortar has traditionally been put between layers of a floor to "deafen" it. The floors in the Merchant Exchange in Philadelphia, already described, and Tremont House in Boston were built this way. The practice of putting in a thicker layer of mortar, to serve as a fire as well as sound barrier, continued until the third quarter to the century at least.¹⁰⁹ Another safeguard, to reduce the chances of a fire spreading laterally, was to divide the space within a building with vertical barriers -- partitions that were solid brick walls rather than the usual wood and plaster. Sometimes these walls were finished with plaster laid directly on the brick rather than on wood lath. Isaiah Rogers built such a firewall between the two wings of his Tremont House (1828-29).¹¹⁰ The Wadsworth Atheneum in Hartford, designed by Town and Davis (1842-44), also is divided by interior firewalls; these walls divide the building into three separate compartments, each with its own entrance.¹¹¹ Similarly, the plan for the Old Yale College Library, built 1842-47 and designed by Town's sometime collaborator, Henry Austin (1804-1891), provided for firewalls between the central building and the two wings.¹¹² Ithiel Town applied this principle in his own house in New Haven on Hillhouse Avenue (c. 1832), which contained his valuable library and art collection. The house is described in an 1839 magazine article as "substantially fireproof," having interior partitions of brick, with plaster laid directly on the walls without lath, and floors covered with two inches of mortar and "water cement" (presumably *hydraulic cement*).¹¹³

¹⁰⁹ An insurance company inspector wrote that the floors in many of the buildings built after the 1872 fire in Boston were protected with layers of mortar. (John E. Whitney, AABN vol. 19 (May 22, 1886), p. 251.

¹¹⁰ Description of the Tremont House.

¹¹¹ Jane Davies, "Wadsworth Atheneum's original building..." Wadsworth Atheneum Bulletin (Spring, 1959), pp. 16-17. Thanks to John Teahan, Wadsworth Atheneum librarian, for sending me information about the building.

¹¹² By a Member, Sketches of Yale College (New York: Saxton and Miles, 1843), pp. 100-101 (thanks to Yale Archives for this reference); George Seymour, New Haven, pp. 219-230. This building is still standing and is called Dwight Hall.

¹¹³ Lydia Sigourney, reprinted in George Seymour, New Haven. Seymour says Alexander Jackson Davis, Town's partner at the time the house was built, designed the house (p. 705). But he must be referring to the exterior.

This approach of creating barriers was intended to contain a fire so that it could be fought. Buildings so constructed were not considered fireproof, but they were more secure than ordinary buildings and much less costly than thoroughly noncombustible ones.

It is impossible to say how well these compartmentalized buildings worked from a fire resistance standpoint. The approach of constructing barriers within an ordinary building was essentially the same as the "semi-fireproof" and "slow-burning" systems that evolved in latter part of the century. But this approach required that people be available to come to suppress a fire before it burned too long. The fireproof buildings, on the other hand, were not supposed to be injured by fire; in theory, a fire in a fireproof building should burn itself out without breaking outside the building.

End of the System - 1850

In the 1840s, new methods of building fireproof began to be used which overcame many of the problems and inefficiencies in the solid masonry method of construction. In the 1840s, Americans began to fireproof buildings using an iron and brick arch system modeled on the British style of fireproof construction. The high cost of iron in the U.S. prevented an earlier introduction of this system, except in a few small buildings. Iron became much more available in the 1840s and began to be used in more as a building material, as will be discussed in the next chapter.

Additionally, the introduction of the new system had to await the end of a depression that followed the panic of 1837 and a second economic downturn in early 1840s, during which time there was little new construction across the nation, fireproof or not.¹¹⁴ During this slow period, the vault architects survived on government work and the building projects already underway. Mills and Young supervised federal government buildings, and Rogers

¹¹⁴ Data on cycles in the building industry from this time are hard to come by. The lack of work for designers seems as good evidence as any that construction had fallen off. There is some quantitative data for Philadelphia: counts of buildings erected by year from 1833-1851, reported in the Philadelphia Public Ledger, January 2, 1852, show a sharp drop in the panic year of 1837, and a second trough in 1842. Construction recovered in 1845, with 552 buildings for the year, and stayed at about 500 or more thereafter. (Numbers in Constance Greiff, John Notman, Architect, 1810-1865 (Philadelphia: Athenaeum of Philadelphia, 1979), fnt. 42 p. 48.)

finished the Boston Merchant's Exchange. Town died in 1844. Willard was mainly occupied with his quarries. Parris and Walter both traveled to Washington in search of government commissions, but neither was successful. Parris ended his career designing engineering works, lighthouses and projects at the Portsmouth, New Hampshire, Navy Yard.¹¹⁵ Walter went bankrupt and took work outside the country for a period.¹¹⁶

The construction picture improved in the second half of the 1840s, during which time some of the last vaulted fireproof buildings were constructed. In 1846, Walter received a commission for a court house for Chester County in West Chester, Pennsylvania, and he designed a building with a vaulted basement and first story.¹¹⁷ The building had the by now "ordinary" accouterments of fireproof buildings: iron doors hung in iron frames, iron shutters, and a metal covered roof.¹¹⁸ Also in that year, George M. Dexter (1802-1872) designed a one story addition to the Massachusetts General Hospital in Boston, to be used for a kitchen and laundry, which had a vaulted cellar. At the same time, extensions containing patient wards were added to the wings of the building, and these were not vaulted.¹¹⁹ In 1851, Walter took over the work on the vaulted east wing of the Patent Office, which had been under construction for about two years, after he won the commission for the extension of the U.S. Capitol. Strickland's career also revived in 1845, when he was selected to design the Tennessee state capitol building. He moved to Nashville to superintend this large project and remained there the rest of his life. The building combines the old and the new styles of fireproof construction: it is vaulted but has an iron roof.¹²⁰ Completed in 1859 by Strickland's son Francis several years after his father's death, it may be the last vaulted masonry fireproof building constructed in the U.S.

¹¹⁵ Edward Zimmer, Alexander Parris.

¹¹⁶ James O'Gorman et al., Drawing Toward Building, pp. 76-77.

¹¹⁷ Edwin Betolett, "Fireproof Construction in Philadelphia."

¹¹⁸ Specifications, West Chester, Pennsylvania Court House, Feb. 25, 1846, Philadelphia Athenaeum, T. U. Walter collection, papers, box 8.

¹¹⁹ Drawings by Dexter are owned by the Boston Athenaeum.

¹²⁰ Agnes Gilchrist, William Strickland.

Few architects designed vault buildings. Those that did were technically oriented men who were able to combine their experience with information gained from books and observation to create novel forms. While the architects in the mid-Atlantic learned from Latrobe, who brought the knowledge over with him, the pioneer vault builders in New England -- Parris, Town, Willard, Young -- learned from reading and observation. Nevertheless, with the exception of Mills, what these men had in common was experience in the building trades and what might be called a technical orientation, a willingness to experiment. Some -- Latrobe, Mills, Parris, Strickland, Town, Walter, and Willard -- worked on engineering projects as well as buildings.¹²¹ They were limited in how experimental they could be. They had no way to test new methods and the consequences of failing -- a cracked wall, a collapsed arch -- could be ruinous. They tried new ideas but stuck to those that had proved successful elsewhere.

The vault building had so many drawbacks that it may seem superfluous to have to explain its demise. But one additional factor changed in architectural taste. The classical temple fell out of fashion as critics ridiculed the indiscriminate reproduction of temples for every kind of purpose and urged instead Gothic or "modern" classical (Renaissance revival) styles. The popularity of the classical style began to wane in the 1840s and with it practically the only appropriate architectural expression for solid masonry buildings.

Meanwhile, the economic recovery and the introduction of a more practical system of construction, demand for fireproof buildings increased. The younger of these vault architects, who continued to practice in the 1850s and 1860s, quickly adopted the new system of fireproof construction which used structural iron -- previously a rarely used material.

¹²¹ Latrobe designed canals and waterworks; Mills designed canals in South Carolina and the Washington Monument in Washington; Strickland, a member of the Franklin Institute, was selected to travel to England in 1825 to study engineering works there; Parris designed mill-type buildings at the Navy Yard in Charlestown; Town built bridges and patented a much used bridge truss; Walter designed a breakwater in Venezuela; and Willard managed quarries and designed machinery for handling stone.

Chapter 3.

Introduction of the Iron and Brick Fireproof Building in the U.S., 1840-1870

Introduction

Several great fires occurred during the 1830s and 1840s. The Manhattan fire of 1835 was one of the most costly in U.S. history. Three years later, half of Charleston burned down, bankrupting local fire insurance companies and convincing the state to relax policies that discouraged out-of-state fire insurance companies from doing business there. Lower Manhattan was again struck by fire, although with less destruction, in 1845. In the same year, several hundred buildings in Pittsburgh burned. St. John in New Foundland, Nantucket Island, Albany, and St. Louis, all experienced serious blazes. The fires continued in the early 1850s, when St. Louis (again), Philadelphia, and San Francisco suffered conflagrations, and part of the Capitol, including the Congressional library, burned.

By this time, a new method of constructing fireproof buildings, which had many advantages over the vault system used in the U.S., had been perfected in Great Britain. This new method employed iron for posts and beams, rather than masonry walls and piers. This system -- what I will call the iron and brick system -- had been introduced in England in 1793 and by the 1840s, its use was widespread in Britain. While it had first been used in industrial buildings, by the 1840s it was used in institutional buildings as well. In the U.S., on the other hand, iron was hardly ever used structurally before the 1840s. By the time Americans began to use the iron and brick system, they could take advantage of several decades of British experimentation and improvement of the system.

Since the terms *girder*, *beam*, and *joist* will be used constantly in this section and hereafter, they need to be defined. These are all horizontal parts of the structure of a building used to support the floor and roof. The word beam is the most general; any horizontal (spanning) member may be called a beam. Girders are large beams; beams are usually called girders when they are used to carry smaller members. For example, in floors with larger members spanning between supports and carrying smaller members, the large members are

called girders and the smaller ones joists. To span long distances, girders may be built up as a *truss*, which is a horizontal member fabricated from several smaller pieces. These terms evolved for wood construction but were applied to iron when it was substituted for wood.

Start of the Iron and Brick Fireproof System in Britain

There is a large literature on the introduction and development of the iron and brick system in British industrial buildings, which it is unnecessary to repeat.¹ The main point with respect to the development of the system in the U.S. is that it had been introduced and had almost 50 years of development in Britain before it was adopted by Americans. The pioneer building of this type was a cotton spinning mill built 1792-93 in Derby, in the north Midlands, by the manufacturer and inventor William Strutt (1756-1830). Its significance was appreciated early on; a mere decade after its construction it was called "the first fireproof mill that was ever built."² Strutt built two other buildings in the 1790s on a similar plan: a warehouse in Milford and a mill (West Mill) in Belper. These buildings are among the earliest examples of the system.

In these buildings, designers tried to replicate a traditional timber interior structure using noncombustible materials. Instead of wood joists, the fireproof buildings had shallow brick arches, called segmental or "jack-arches," which sprang between girders. (Illustration 3-1.) These arches were much heavier than wood floors but they were roughly half the weight of floors in solid masonry buildings.³ Since the shallower arch exerted more outward thrust than did barrel vaults, the beams had to be tied with iron rods. Strutt did not originate this system of construction: floors made of brick arches between wood beams, such as Strutt used

¹ A recent survey can be found in Keith Falconer, "Fireproof Mills -- The Widening Perspectives," Industrial Archaeology Review vol. 16 (Autumn, 1993), pp. 11-26.

² Quote from the 1802 The Beauties of England and Wales, in H. R. Johnson and A. W. Skempton, "William Strutt's Cotton Mills, 1793-1812," Transactions of the Newcomen Society, vol. 30 (1955-56 and 1956-57), p. 180.

³ The floors in Robert Mills' Pennsylvania State House Row were estimated to weigh 213 pounds per foot. The weight of English masonry floors varied with the size of the bricks used and the weight of the filling put over the haunch of the arch. But when a standard (English) sized brick was used and the haunch filled with some sort of concrete, this floor weighed about 115 pounds per foot. (J. R. Freeman, "Comparison of English and American Types of Factory Construction," Journal of the Association of Engineering Societies vol. 10, remarks presented September 17, 1890.)

in the Derby mill, had been built in Paris since at least the 1770s.⁴ However, in France, the beams probably spanned between walls, while Strutt's girders spanned from wall to column to wall, as in the larger wood-framed mills.

Illustration 3-1. Section of a floor: brick segmental arch between I beams. The material over the arch is concrete. Wood nailing strips are set in the concrete and the floor is laid on top. The arch is tied with a rod.

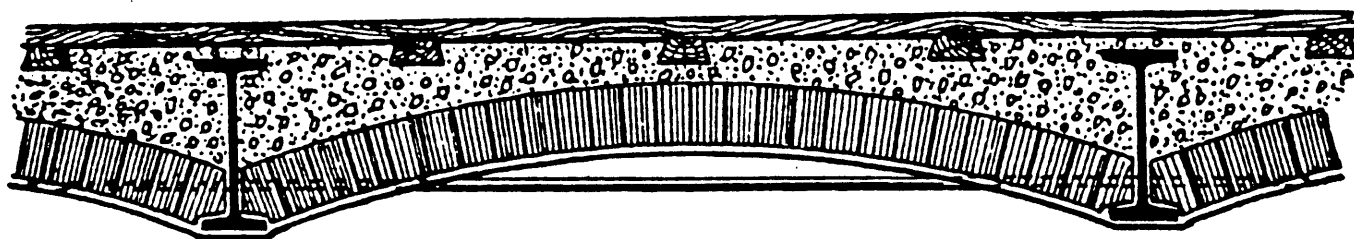


FIG. 1.—Brick Arch.

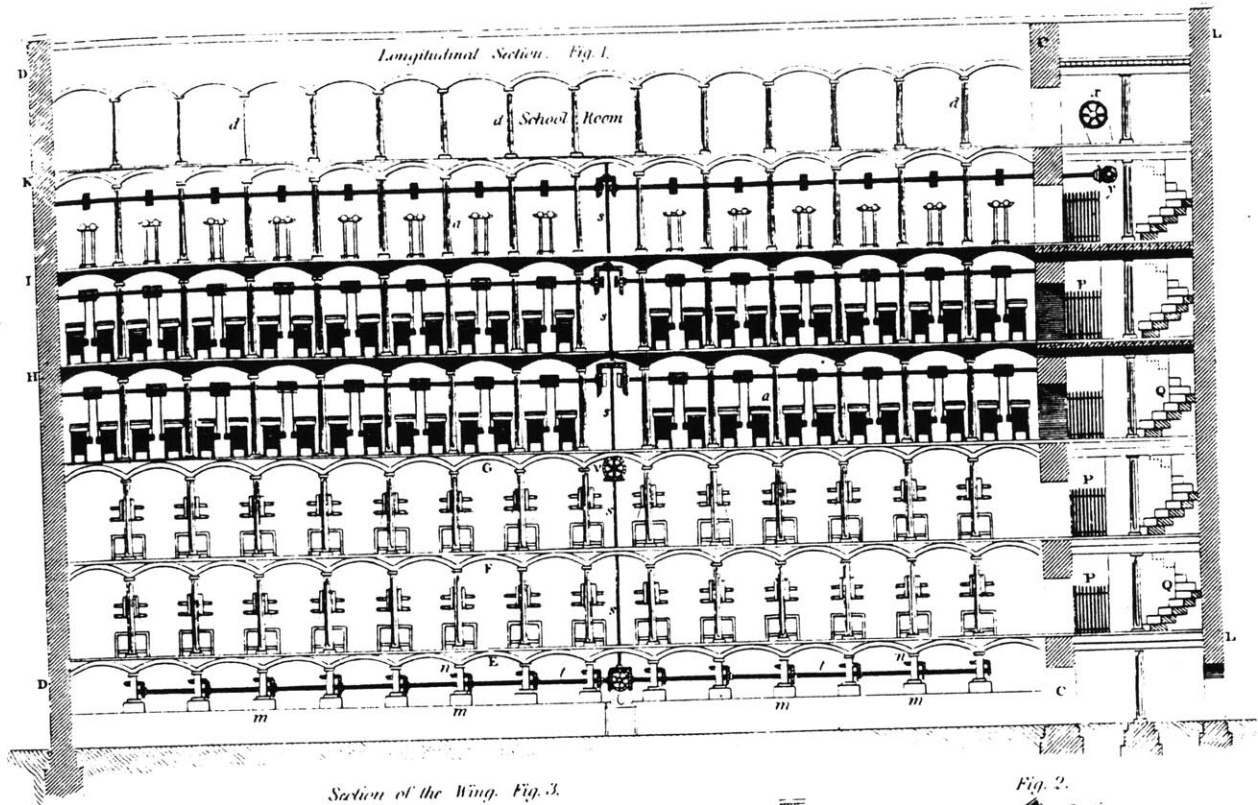
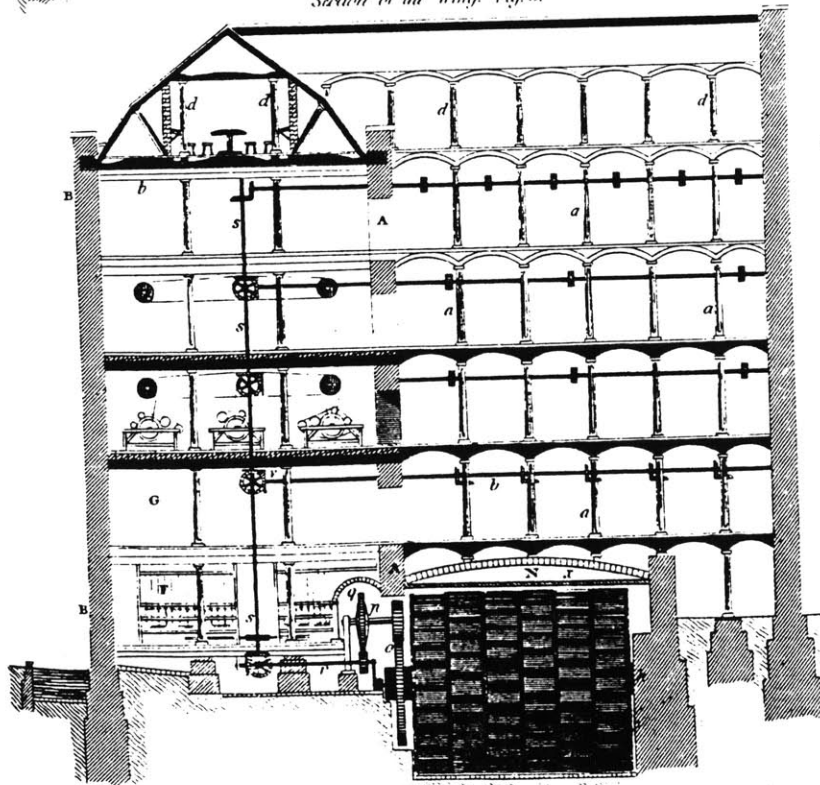
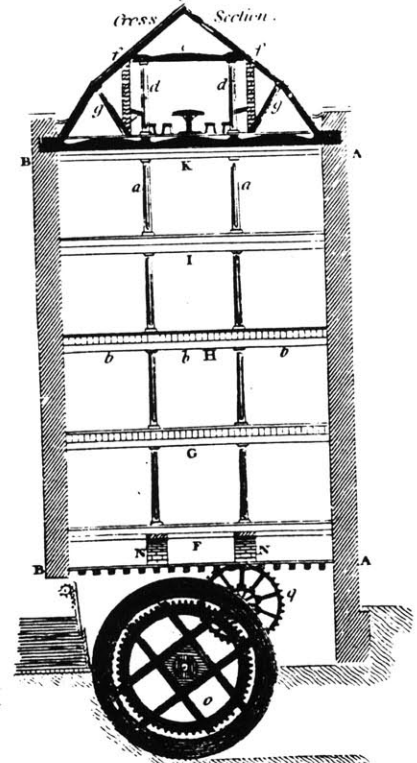
The manufacturer and building designer Charles Bage (1752-1822) improved his friend Strutt's fireproof floor by substituting cast iron beams for wooden ones in his 1796-1797 Ditherington flax spinning mill.⁵ This mill was located in Shrewsbury, a center for development of structural cast iron manufacture. Iron beams as well as posts became standard for fireproof mills in Britain thereafter. The essential features of these buildings were masonry exterior walls carrying cast iron beams that were supported on the inside of the building by cast iron columns, and brick arched floors. In some of the buildings, the roofs were framed with iron, but this was not a universal feature. (Illustration 3-2.)

The iron and brick system was revolutionary from the standpoint of fire protection, but considered structurally, it employed iron like wood -- iron joinery, as one architect called it. However, structural iron did present several new problems. For one thing, building designs had to be more precisely detailed when iron was used because, unlike wood, it is not a forgiving material. Replacing a piece of iron that is too long or too short was an expensive

⁴ S. Wermiel, "The Development of Fireproof Construction in Great Britain and the United States in the Nineteenth Century," Construction History vol. 9 (1993), p. 7.

⁵ The building was recently surveyed by researchers at the Ironbridge Institute in Telford, England. The sequence of development of the fireproof mills was discussed by Jennifer Tann, The Development of the Factory (London: Cornmarket Press, 1970) in the chapter "Evolution of the fireproof factory."

Illustration 3-2. English fireproof factory.

*Section of the Wing. Fig. 3.**Fig. 2.*

proposition. Connections between columns and beams were a particular problem: there was no precedent for it in wood and some of the early solutions were insecure. Also, designers knew little about how the material performed under loads. Thus the technical problems connected with using iron structurally pertained to its performance, i.e., how much weight it could bear and what shapes were strongest. A final problem with using iron concerned its manufacture: the techniques for making large, reliable castings, and shaping large pieces of malleable iron, took long to develop.

The brick arch floors were costly yet had no advantages other than being fireproof, a situation that hindered their adoption. In fact, as floors, they were over-built. Although the system was used in buildings that customarily had heavily loaded floors, like warehouses, or had to withstand vibration from machinery, like mills, timber could have been used just as well. Wood floors -- cheaper, lighter, and taking up less head-room -- could bear the required loads and did, since most British mills in the first half of the nineteenth century were built with traditional timber framing. In other words, there was no structural necessity or even advantage to build with iron and brick. Indeed, in the U.S., the system was used almost exclusively in non-industrial buildings, which did not have heavily loaded floors. The cost and lack of advantage, other than greater safety from fire, prompted Bage to search for less expensive methods of fireproof construction, for example "brick beams;"⁶ these apparently were not successful and iron continued to be the material of choice. In the decades that followed Bage's first iron-framed mill, invention went in the direction of improving iron beam and column sections, so as to concentrate the material where it would do the most structural work.

Use of the Iron and Brick System in Non-industrial Buildings

British architects (as distinguished from designers of mills and warehouses) began to use structural iron in nonindustrial buildings by the last quarter of the eighteenth century⁷ but did not use it in a system of fireproof construction until about the 1820s. Not coincidentally, at the beginning of this decade (1822), Thomas Tredgold, author of books on carpentry and

⁶ Jennifer Tann, Development of the Factory, chapter on fireproof factories.

⁷ Turpin Bannister, "The First Iron-Framed Buildings," Architectural Review vol. 107 (1950), pp. 231-246.

other technical textbooks, published A Practical Essay on the Strength of Cast Iron, which contained "practical rules, tables, and examples" for calculating the bearing strength of iron.⁸ He listed several reasons why iron should be preferred to wood, including permanence, durability, and its ability to be molded, but "safety against fire" topped the list. Tredgold expected iron to be used in various applications, but while iron columns were used as posts in churches, theaters, and dwellings as well as factories and warehouses, iron beams were used mainly in fireproof construction, which at that time was limited to mills and warehouses. This book met a need for information on the resistance of iron beams. A second edition came out two years later, and two more editions were published posthumously. The book was translated into French, Italian, and Dutch, and was knocked off in a supposedly more accessible English version in 1832⁹ -- all of which suggests that the book was well-known and probably played a major role in the spread of the iron and brick system into the world of architecture.

Tredgold was self-taught and his resources for conducting tests on the strength of materials were limited. He concluded that the best section shape for cast iron beams was an I shape with symmetrical flanges rather than the inverted T or V shapes that were used in the first fireproof mills. These early sections were not designed for efficiency but rather to carry the arched brick floors.¹⁰ Tredgold reasoned that cast iron was a uniform material and equally strong in tension and compression, therefore a symmetrical shape was best.

Because so many different beam sections are found in early British fireproof buildings, and because the efficiency of various sections was the topic of some early and important research into the strength of materials, there is a large literature on the evolution of cast iron

⁸ Thomas Tredgold, A Practical Essay on the Strength of Cast Iron... (London: J. Taylor, Architectural Library, 1822).

⁹ William Turnbull, A Treatise on the Strength, Flexure, and Stiffness of Cast Iron Beams and Columns (London: J. Taylor, Architectural Library, 1832).

¹⁰ So says Hodgkinson in part II of his 1842 edition of Tredgold. See also R. J. M. Sutherland, "Pioneer British Contributions to Structural Iron and Concrete: 1770-1855," in Charles Peterson, editor, Building Early America (Radnor, PA: Chilton Book Co., 1976).

beam sections.¹¹ The scientist Eaton Hodgkinson (1789-1861) conducted the tests to determine the strongest section for cast iron beams at the Manchester engineering works of his friend William Fairbairn (1789-1874). Fairbairn's business at the time was mill construction, and he provided the materials and facilities for a series of tests. The results were reported in 1831 in a paper read to the Manchester Literary and Philosophical Society, and published in its Memoirs. Hodgkinson concluded that an asymmetrical section having a lower flange several times wider than the top, was a stronger form for cast iron.¹²

Coincidentally, this also happened to be a common form of beam; a flange was attached to the bottom only, simply to carry the arched brick floor. How well this article was known within, let alone outside, the mill world is hard to judge, since I-section beams continued to be used in buildings after this date. But Hodgkinson's results did get wider circulation in 1842 in a new edition of Tredgold's Practical Essay, which Hodgkinson annotated and expanded. He added an original, new section explaining his experiments and findings, which he boiled down to the simple formula of a 7:1 ratio of the bottom to the top flange of a cast iron beam as giving the greatest resistance to fracture. This section, part II of Tredgold, also was published separately in 1846.¹³

Although the post, girder, and brick arch system was the most common one in fireproof industrial buildings, it was not the only one. An alternative form, used in the 1820s and 1830s, consisted of an iron framework of T section spanning members, filled in with large flag stones. Perhaps the first instance of this floor in England was in a steam-powered sawmill designed for the Royal Dockyard at Chatham in 1811.¹⁴ The iron framework for the floor consisted of iron girders of inverted T section with arched webs, thinner at the ends

¹¹ A good overview of the topic can be found in Ron Fitzgerald, "The Development of the Cast Iron Frame in Textile Mills to 1850," Industrial Archaeology Review vol. 10 (Spring, 1988), pp. 127-145.

¹² Eaton Hodgkinson, "Theoretical and experimental researches on the strength and best forms of iron beams," Manchester Literary and Philosophical Society Memoirs, 2nd series, vol. 5 (1831), pp. 407-544.

¹³ Eaton Hodgkinson, Experimental Researches on the Strength and Other Properties of Cast Iron (London: John Weale, 1846).

¹⁴ Jonathan Coad, The Royal Dockyards 1690-1850 (Aldershot: Scolar Press, 1989), p. 34, 237-239. I am obliged to B. L. Hurst for calling the sawmill and the spinning house at Plymouth to my attention, and for sending me a photo of the sawmill.

that attached to the iron columns and deepest in the center. Brackets were cast at intervals along the length of the web, which held iron joists. These joists were double-flanged, wider at the top, which supported the stone floor; the narrow bottom flange was most likely designed to hold the joist securely in its bracket. The joists were flat on their upper side and arched on the other. The building was the work of Marc Brunel (1769-1849) and Edward Holl (?-1824) who was an architect and engineer for the dockyards from 1804 until his death. The sawmill was ready for use in 1814. The following year, Holl planned a new building for the rope works at the Royal Dockyard in Plymouth, on the southwest coast of England, which had floors like the ones in the Chatham sawmill: large, arched iron girders spanned from the outside walls to center columns across the short dimension of the building, and iron joists that fit into brackets in the girders ran longitudinally. The framework was then filled in with large flag stones.¹⁵

In the 1830s, iron began to be rolled in long pieces, for use as railroad rails. Up to this time, wrought iron -- the type that can be rolled -- was used in a small way, structurally: in iron clamps, tie rods, and nails -- for connection and restriction, as James Sutherland sums it up.¹⁶ But as it was used in rails in place of cast iron, its great superiority to cast iron in tensile strength began to be appreciated. Wrought iron is a form of iron that is practically free of carbon, the element that makes iron brittle. Carbon is commonly found in iron to some extent and it remains in the iron that is removed from the ore. It makes iron crystalline, and therefore strong when compressed. When carbon is removed from iron, it is malleable, workable -- hence the name "wrought" -- and it is shaped by hammering, squeezing, rolling, and cutting. But the small amount of carbon in cast iron is what allows it to melt and to be shaped in molds. While cast iron can not be shaped by bending, it can be machined, for example ground smooth or drilled. The technology for making very large structural shapes by casting them developed much earlier than technology for rolling; consequently, the earliest beams and columns were cast iron. The bending action of wrought iron makes it better

¹⁵ J. Coad, The Royal Dockyards, pp. 200-201.

¹⁶ R. J. M. Sutherland, "The Introduction of Iron Into Traditional Building," in Hermione Hobhouse and Ann Saunders, editors, Good and Proper Materials (London: The Royal Commission on the Historical Monuments of England, 1989), p. 48.

adapted from spanning applications, while cast iron is best used for structural parts in compressions, like columns, posts, and short lintels.

Wrought iron was much more expensive than cast iron, however, so it would be used in cases where the designer could take advantage of the smaller section and reduction of weight it permitted. One of the first uses in England of wrought iron as spanning members was as joists, in a T shape, such as a rail, but with the flange at the bottom and filled in with flag stones to the depth of the web. This particular style of floor was used to a small extent in industrial buildings in the 1830s, for example in some sugar refineries.¹⁷ These iron grid floors probably were introduced to reduce the weight and depth of floors and increase the floor area between columns.¹⁸

Despite the advantages, this system was little used in industrial buildings. The savings in floor weight and headroom presumably was offset by the greater cost of the grid floor, and rows of columns, apparently, were no great functional hindrance in mills and warehouses.

However, the aesthetic effect of rows of columns was a concern for architects, who preferred clear spans. They often used a girder and joist system, with arches between the joists, rather than the simple girder and arch of mills and warehouses, thereby creating larger spans between columns.¹⁹ Alternatively, they made rooms narrow enough to be spanned from wall to wall without intervening columns.²⁰

An early example of an attempt at structural fire protection in a nonindustrial building that illustrates the long span approach was the new Museum at Edinburgh University. It was

¹⁷ Luke Hebert, The Engineer's and Mechanic's Encyclopaedia vol. 1 (London: Thomas Kelly, 1836), pp. 526-27.

¹⁸ Colum Giles and Ian H. Goodall, Yorkshire Textile Mills; the Buildings of the Yorkshire Textile Industry, 1770-1930 (London: HMSO, 1992), p. 64.

¹⁹ While the history of industrial buildings has been the subject of many studies, there is no study of the history of non-industrial fireproof buildings in Great Britain. A survey of the entire field of British structural fireproofing methods, from the 18th through the 20th centuries, can be found in S. B. Hamilton, A Short History of the Structural Protection of Buildings Particularly in England, National Building Studies, Special Report No. 27, Department of Scientific and Industrial Research (London: HMSO, 1958). This study, and similar surveys, catalogue the variety of methods used but do not attempt to determine how extensively any of the systems were used.

²⁰ Thanks to Arnold Pacey for calling my attention to these different approaches.

designed in 1817 by the Scottish architect William Henry Playfair (1790-1857).²¹ The second floor of the building consisted of iron girders spaced about 8 feet apart, spanning about 30 1/2 feet, which was the narrow dimension of a rectangular room. Instead of filling in with joists and flag stones, like Brunel and Holl did in their Chatham sawmill, Playfair used plates made of cast iron, which served both as joists and bearing surface.²² The plates were roughly 8 foot by 3 foot plates and their edges were cast in the shape of the joists used in the Brunel/Holl floor; they were covered with carpets. Whether Playfair knew of the earlier example, I can not say. The floors were made by a foundry in Scotland.

The girder and joist fireproof floor was used by architect Robert Smirke (1780-1867) in several important government buildings in the 1820s. By 1816, Smirke had designed a floor made of iron girders with brackets cast on the top edge, similar to the Brunel/Holl design, but rather than filling in with wrought iron joists and flag stones, he used wood joists and planks. This floor was not fireproof; the purpose of the iron girders was to span a large distance without sagging. A little later, for the King's Library in the British Museum (1823-25) and General Post Office (1823-29), both of which were designed with great attention to safety from fire, he introduced a similar iron and wood floor but shielded the wood by installing arched iron plates underneath them.²³ The plates in the King's Library were 1/8 inch thick and were carried on the flange of the beams. Unlike Playfair's floor, the iron plates serve only to protect the wood floors and are not load bearing; why Smirke made them arched, therefore, is a question. Smirke used this floor system again in 1825-28 in his reconstruction of the London Custom House following the collapse of a floor in the center of the building. (Illustration 3-3.) The wooden roof of this building was also protected by a

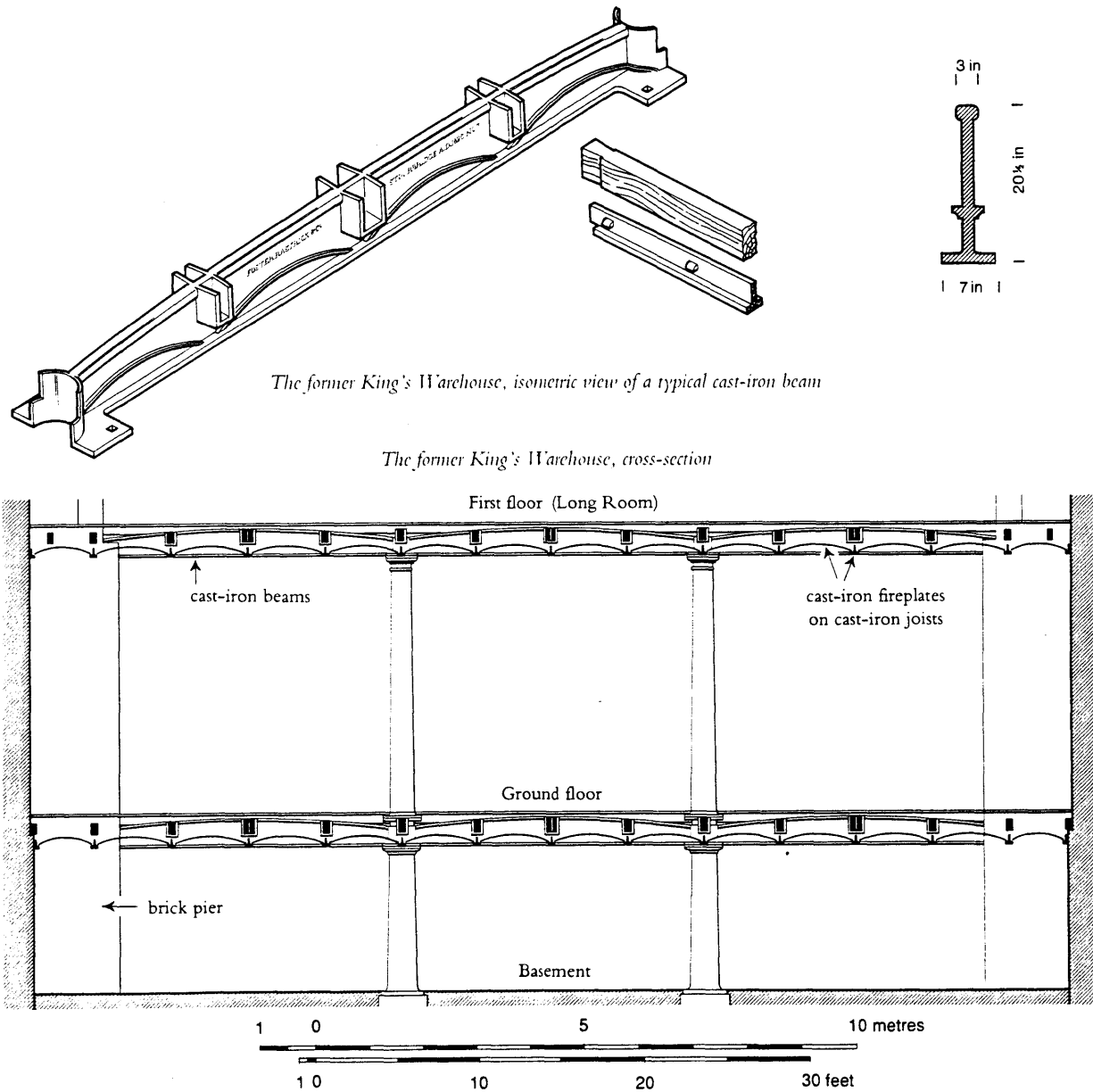
²¹ Biographies of Playfair all mention that he may have worked with Smirke in London, but no one seems to know for sure.

²² Andrew Fraser, The Building of Old College: Adam, Playfair, and the University of Edinburgh (Edinburgh: Edinburgh University Press, 1989), chapter 7. Thanks to Arnold Pacey for bringing this building to my attention.

²³ R. J. M. Sutherland, "The Age of Cast Iron 1780-1850: Who Sized the Beams?," in Robert Thorne, editor, The Iron Revolution, Essays to Accompany an Exhibition at the RIBA Heinz Gallery, June-July 1990, p. 26; Royal Commission on the Historical Monuments of England, The London Custom House, c. 1993, p. 10; J. Mordaunt Crook, The British Museum (New York: Praeger Publishers, 1972), pp. 141-142.

barrier of iron plates. The plates were flanged at the edges and bolted together,²⁴ not unlike Playfair's floor for the Edinburgh Museum.

Illustration 3-3. Iron girders with wood joists, used in the London Custom House (1825-28). Iron arched plates are held in the arched rib that runs along the lower edge of the girder.



Brick arches were used as filling between iron joists in the nonindustrial fireproof

²⁴ Royal Commission, London Custom House, pp. 20-23.

buildings. For example, the architect Charles Barry (1795-1860) designed brick arches to go between iron beams in the Houses of Parliament, reconstructed after the fire of 1834, and in sections of his 1837 Reform Club building in London.²⁵ As an architect wrote in 1872, "Among my early experiences no building was considered fire-proof that had not iron joists and brick arches."²⁶

Ironically, by the time American architects began to adopt the iron and brick system, British architects were beginning to abandon it. During the time it was the universal standard of building fireproof, before the 1850s, few buildings in Britain -- even industrial buildings -- were built this way. Even with the great abundance of iron, made possible by technological improvements in smelting, iron was still considerably more expensive than wood. What proved fatal to the system's continued use was that by mid-century some people began to criticize it as dangerous. One influential critic was the head the London Fire Brigade, John Braidwood, who found fires in iron warehouses particularly difficult to control. While British architects began to adopt methods of building fireproof in place of the iron and brick system, it began to be more widely used for industrial buildings, and was the standard system for building factories until the end of the nineteenth century. By contrast, in the United States, iron and brick was used almost exclusively for nonindustrial buildings in the nineteenth century, almost never for industrial buildings.

Structural Use of Iron in the United States Before 1840

Iron was used very little structurally in the U.S. before 1840 because of its cost, not for lack of information on British developments. Descriptions of English fireproof buildings were available in British and American publications, and a few English textbook on how to use iron in building was available. Alexander Parris and Loammi Baldwin owned copies of Tredgold's textbook on iron; Parris sold his copy to the Boston Athenaeum, a social club with a library, in 1826. Parris and Charles Bulfinch owned copies of Charles Sylvester's 1819 pamphlet on the Derbyshire Infirmary, in which the author declared that Strutt's method of "rendering buildings fire proof by substituting iron and brick in place of wood" was the most

²⁵ John Olly, "The Reform Club," The Architects' Journal vol. 181 (February 27, 1985), p. 43.

²⁶ Building News vol. 22 (March 29, 1872), p. 250.

important modern discovery.²⁷ American textile manufacturers, too, were eager for information concerning British methods of mill construction and some had seen the British fireproof mills for themselves. In 1825, before he commenced his career in textile manufacturing, Zachariah Allen took a "practical tour" of British textile centers and in 1832, published an account of the trip. A fireproof mill in Leeds obligingly caught fire when he was in town and he noted that it held up well.²⁸ Hodgkinson's important 1831 paper was reprinted in the Journal of the Franklin Institute (JFI) the year after it came out in England.²⁹ The JFI published other articles by Hodgkinson concerning cast iron as they came out. Americans followed the example of the British engineers and conducted tests of American iron. In 1836, following the conflagration in lower Manhattan, New York merchants pressed Gouverneur Kemble, one of the owners of West Point Foundry, for information on the cost of using iron rather than wood to rebuild their buildings. Kemble sponsored tests on the strength of beams cast of American iron for fireproof buildings, which were witnessed by Thomas J. Cram, then a science and math instructor at the U.S. Military Academy, who wrote a report of the results that was published in JFI. The West Point tests generally confirmed Hodgkinson's finding that in cast iron an asymmetrical beam section was most efficient.³⁰

However, neither Allen's textile mills nor the New York merchants' stores were built with iron for the simple reason that iron was too costly a material to use so extensively. Once an exported of pig iron to Britain, American production technology had fallen far

²⁷ Charles Sylvester, The Philosophy of Domestic Economy...Adopted in the Derbyshire General Infirmary (Nottingham, 1819), p. 7. Bulfinch's copy is in the collection of M.I.T.'s Rotch Library. Baldwin's copy of Tredgold is also at M.I.T.

²⁸ Zachariah Allen, The Practical Tourist (New York: Arno Press, 1972), reprint of 1832 edition.

²⁹ Eaton Hodgkinson, "Theoretical and Experimental Researches to Ascertain the Strength and Best Forms of Iron Beams," JFI vol. 9 ns (1832) and vol. 10 ns (1832), in parts.

³⁰ A. D. Bache, "Report of Thos. Jefferson Cram ... upon experiments relative to the strength of Cast-iron beams," JFI vol. 18 (Sept., 1836), pp. 153-157. Americans did not adopt the arched shape and parabolic flanges of Hodgkinson's ideal cast iron girder, partly, I guess, because large wrought iron I section beams became available early in the history of iron building construction, which were preferred to cast iron. English-style cast iron girders may have been used in the 1850s in bridge work. B. H. Latrobe, II, chief engineer of the Baltimore and Ohio Railroad, is credited with designing the "first fish-bellied girder constructed of cast and wrought iron," which sounds roughly like the English girder, in elevation at least. (Theodore Cooper, "American Railroad Bridges," ASCE Transactions vol. 21 (July, 1889).) But cast iron ceased being used for spanning members for bridges as it was found that exposure to the weather, sudden impacts, and varying loads weakened the metal.

behind that of Britain. The greater quantity of iron in Britain, and comparatively lower cost, allowed the British to use iron in a greater variety of ways, such as structural castings. The key to expanded iron output in Britain was the development of coke smelting, but Americans did not use coke until the second half of the nineteenth century.³¹ Differences in the nature of American resources -- the absence of coking coal in the principal early iron producing center -- prevented Americans from adopting British smelting practice, and American pig iron output was far below domestic demand. Moreover, American-made iron cost more to make than imported iron, leading the nation's iron masters to lobby Congress for high tariffs on all iron, bar and pig iron as well as manufactured iron products.

Nevertheless, despite the disincentives, a few adventurous designers introduced iron in their buildings before the 1840s, although very sparingly. Probably the earliest use of iron columns were used to hold up balconies in churches and theaters. They also began to be used in mill buildings, in the 1830s.³² Iron columns were used for trestles on the Baltimore and Ohio railroad in the 1840s.³³ In these early cases, iron columns probably were selected for their strength rather than for their fire resistance. (A short column, with a ratio of diameter to length of ten or less -- e.g., ten inch diameter for an eight foot length, made of cast iron is about sixteen times stronger than a column of the same size made of the stoutest oak.³⁴) However, in some cases they were chosen for their fire resistance. William Strickland

³¹ Peter Temin, Iron and Steel in Nineteenth Century America: An Economic Inquiry (Cambridge: M.I.T. Press, 1964), chapter 3.

³² Early American buildings with cast iron columns include: Latrobe's 1808 Christ Church in Washington; Strickland's 1820-22 Chestnut Street Theater in Philadelphia; Richard Bond's 1826 Green Street Church in Boston; and Parris' 1827-28 Stone Temple in Quincy, Massachusetts. (Agnes Gilchrist, William Strickland (Philadelphia: U. of Penn. Press, 1950) p. 61; Edward Zimmer, The Architectural Career of Alexander Parris (1780-1852), PhD dissertation, Boston University, 1984, p. 487.) The No. 1 and 2 Stark Mills in Manchester, New Hampshire (c. 1838-1839) contained "Iron Supports" and the contract with Phineas Stevens for labor on Manchester Mills calls for "setting the Iron posts or supports under the beams." (Amoskeag Manufacturing Co., "Acts of Agreement, Specifications for Mill Buildings, 1838-1839," ms, p. 48 and p. 72, at the Manchester Historic Association.) The c. 1836 Boott Mill in Lowell had cast iron columns. (Letter from Laurence Gross, Oct. 7, 1992.)

³³ James Dilts and Catharine Black, editors, Baltimore's Cast-Iron Buildings and Architectural Ironwork (Centerville, MD: Tidewater Publishers, 1991), p. 7. The bridges are not identified.

³⁴ Thomas Nolan, editor-in-chief, Kidder's The Architects' and Builders' Pocket-Book 16th edition (New York: John Wiley & Sons, 1916), chapter 14.

probably specified iron columns to support the exterior balconies in his masonry vaulted, fireproof Naval Home because they were noncombustible.

Another early use of iron structurally was iron rods, which were used to support wood trusses. An early application of this was in the Faneuil Hall Market building (1824-26), designed by Alexander Parris, where the first floor beams are partly supported by iron rods suspended from the second floor beams. This arrangement was designed so as to reduce the number of supports needed in the basement story. Both these rods and cast iron columns, that hold up the second floor beams, were hidden inside monumental, hollow wooden columns that line the ground floor corridor of the building.³⁵ The practice of placing cast iron columns inside wooden ones, as a reinforcement, was done at the time in England.³⁶ The idea of hanging floor beams from roof timbers came to be widely used in mills; attic floor beams were often suspended from iron rods, leaving the floor below clear of posts.³⁷

Likewise, in bridge building in the U.S. before the 1850s, iron was used very sparingly and mainly to reinforce wood. The first general use of iron was in truss bridges, where iron rods reinforced wooden trusses. Two popular types introduced in the 1840s were the Howe truss, which had iron vertical members, and the Pratt truss, with iron diagonal members.³⁸ Railroads were expanding in the 1840s and iron would seem to be a natural material for railroad bridges, considering that they must support heavier loads and more vibration than highway bridges, and were open to the weather. Even so, most railroad bridges were made of wood; neither the weight of trains in this period nor the geography of the east coast, where most of the miles of track were laid, made iron bridges a necessity. However, a

³⁵ Description of the building's structure from Elizabeth Amadon et al., The Faneuil Hall Markets; An Historical Study, 1968, revised 1969. The cover of this study reads, Faneuil Hall Markets Report, Prepared for the Boston Redevelopment Authority by Architectural Heritage, Inc. and the Society for the Preservation of New England Antiquities. Unfortunately, the columns are not described in this study; in the drawings, they are round with straight sides, like poles. The building has been reconstructed several times, and the original framing apparently is gone.

³⁶ R. J. M. Sutherland, "The Introduction of Iron Into Traditional Building," p. 49.

³⁷ For example, the c. 1839 contract for building the Manchester Mills Picker and Boiler houses specified that "Queen posts to be omitted and Iron Rods substituted in their stead." (Amoskeag Manufacturing Co., "Acts of Agreement, Specifications for Mill Buildings, 1838-1839," p. 72.) The slightly earlier No. 1 cotton mill had queen posts.

³⁸ Theodore Cooper, "American Railroad Bridges," ASCE Transactions, vol. 21 (July, 1889), pp. 1-59.

number of all iron bridges (exactly how many can not be determined) were constructed in the 1840s.³⁹ Two pioneer examples -- both highway bridges built in 1840 over the Erie Canal -- are a combination truss-suspension bridge at Frankford, New York, and an arch-truss bridge built by the famous bridge designer, Squire Whipple. The first all iron railroad bridges were built beginning in 1845.⁴⁰

At this time, iron was selected mainly for permanence and fire resistance, not because wood could not meet performance requirements. The first iron bridges in England, and early American proposals for iron bridges, e.g. Robert Fulton's 1796 designs for iron bridges over canals,⁴¹ long pre-date the appearance of steam-powered railroad engines. In fact, following the collapse of an iron bridge on the Erie Railroad in 1850, on the heels of the failure of the Dee bridge in England, Erie officials took down their iron bridges and replaced them with wooden ones. Use of iron for bridges increased in the 1850s, when it was generally adopted by the Baltimore and Ohio Railroad for its bridges and by the Pennsylvania Railroad its western and mountain divisions.⁴² In addition to the B&O, Erie, and Pennsylvania, iron bridges were built by the New York and Harlem, Boston and Albany, and other railroads.

The First Examples of the Iron and Brick Arch System in the U.S.

A very few examples of British iron and brick fireproof construction appear in the 1830s. Probably the first was a *ropewalk* designed in 1834 by Parris for the Navy Department's boat repair yard in Charlestown, Massachusetts, and constructed from 1835-1837.⁴³ A ropewalk is a building in which rope is made; before machines were invented to

³⁹ Only two iron railroad bridges, dating from 1845-47, have been found still standing. Eric DeLony, "Surviving Cast- and Wrought-Iron Bridges in America," Journal of the Society for Industrial Archeology vol. 19 (1993), p. 45.

⁴⁰ Eric Delony, "Surviving Cast- and Wrought Iron Bridges," pp. 12-13.

⁴¹ Robert Fulton, A Treatise on the Improvement of Canal Navigation...with Thoughts on, and Designs for...Bridges of Iron and Wood (London: I. and J. Taylor at the Architectural Library, 1796), chapter 22. Permanence, durability, and economy were the qualities Fulton sought in his iron bridges, which were designed to cross canals.

⁴² Robert Fulton, A Treatise on the Improvement of Canal Navigation, p. 15.

⁴³ Chronology of development of the building is in Edwin Bearss, Historic Resource Study, Charlestown Navy Yard, 1800-1842, vol. 2, U.S. Department of the Interior, National Park Service (October, 1984), pp. 736-737, 951-963.

spin and wind rope simultaneously, rope had to be stretched out while it was spun. The length of the rope, consequently, was determined by the amount of space available for stretching it. For this reason, rope was often made outside; to make it inside required a very long building.

Rope was vital in this age of maritime commerce and warfare, and ropewalks were very common buildings in seaports, but rope manufacture was a notoriously dangerous business. Boston's commercial ropewalks had been exiled to the foot of the Common in 1794 after a fire that started in one of them burned down a large section of the town.⁴⁴ The rebuilt ropewalks burned in 1806 and were rebuilt, but most burned down again in 1819. The Navy Yard at Charlestown, where black powder and timber for ship building were stored and wooden boats were docked, could hardly afford a great fire. Yet the yard managers invested in structural fire protection only where danger was greatest, such as at the ropewalk. Thus, the floor over the basement rooms where the boilers and steam engines for driving the rope spinning machines were located were made of brick arches on iron beams. Although this building still stands, the fireproof floors have been removed and the basement rooms that housed original engines are inaccessible. However, a drawing Parris made as a record of construction in the yard in the 1830s shows the original construction.⁴⁵ Other fire protection measures in this building are iron window shutters and doors and a slate roof, made by laying slates directly on rafters rather than on boards.

Philadelphia had at least one iron, fireproof building in this decade. John Notman (1810-1865) -- who had probably learned architectural drafting in William Playfair's office in Edinburgh before he emigrated to the U.S. in 1831 -- designed an iron and brick fireproof

⁴⁴ Caleb Snow, A History of Boston 2nd edition (Boston: Abel Bowen, 1828), p. 322.

⁴⁵ Alexander Parris, "Plans of Buildings and Machinery Erected in the Navy-Yard Boston from 1830 to 1840." I examined a microfilm of these drawings (National Archives, T-1023) owned by the Boston National Historical Park, Charlestown Navy Yard. I also inspected the building December 13, 1993, with a Park Service historian. Letters referenced in an article about Parris, in the collection of the Charlestown Navy Yard, indicate that Parris had proposed to build the first and second floors fireproof (Helen Davis et al., "Alexander Parris: The Years with the Boston Naval Shipyard," (February, 1974), p. 16).

building for the Academy of Natural Sciences in Philadelphia which was constructed 1839-40.⁴⁶

Although owners declined to adopt the system, architects nevertheless proposed it when an owner indicated that he wanted a fireproof building, arguing that it was better than the solid masonry system, which was the standard method of building fireproof at the time. For example, in his 1837 competition design for the Boston Custom House, Parris proposed a building with iron beams and brick arches on the second floor, over a lower story covered with circular vaults.⁴⁷ But the building committee selected Ammi Young's solid masonry building. The next year, in his report on the sturdiness of Mills' Treasury Department building, Parris recommended,

that cast-iron beams, with brick arches, be substituted for the groined arches. This flooring is much used in cotton-mills and other structures (where the walls are thin) in England, and requires no thicker wall for its support than floors of timber.⁴⁸

However, Mills completed the building with the solid arches that were his specialty.

Another unexecuted proposal for using iron in a fireproof building was an entry in the 1832 Girard College competition by Robert W. Israel, an ambitious textile mill superintendent. Rather than spanning the upper rooms, intended to be fifty feet in the clear with heavy, masonry vaults, as Stephen Girard specified in his will, Israel proposed making the floors of cast iron "boxes" or blocks -- rather like an arch bridge, but made with iron rather than stone blocks. The boxes would be four feet square with a top and side, or flanges, 9 inches deep. To level the floor, Israel placed small posts, decreasing in length as they approached the center of the arch, at the joints of the boxes. These posts carried a frame of "rails" filled in with marble slabs. It is remarkable that Israel recommended rails, which were

⁴⁶ Constance Greiff, John Notman, Architect, 1810-1865 (Philadelphia: Athenaeum of Philadelphia, 1979). The building was at Broad and Sansom Streets. A facade view exists but no sections, which would show how it was constructed. The Academy does not have any drawings of this original building (all of its architectural drawings are on loan to the Philadelphia Athenaeum at present). Another possible example is market house attributed to William Strickland, which is mentioned by Turpin Bannister ("Bogardus Revisited; Part I: the Iron Fronts," Journal of the Society of Architectural Historians vol. 15 (Dec., 1956) and Peterson. However, no view or description of it survives. See, e.g., Charles Peterson, "Iron in Early American Roofs," Smithsonian Journal of History vol. 3 (Fall, 1968), pp. 41-76.

⁴⁷ Edward Zimmer, Alexander Parris, p. 591.

⁴⁸ U.S. House of Representatives, Report No. 737 (1838), p. 32.

practically a brand new product at the time. All the iron would have been cast.⁴⁹ Israel's arched floor is unique, but it is similar to the iron bridge proposed by Robert Fulton in his 1796 treatise on canals.⁵⁰ Israel, although he was living in Lowell, Massachusetts at the time he made his proposal, was from the Philadelphia area. Philadelphia was engaged in a debate about building a canal or railroad to western markets and chose a canal/portage railroad system, such as Fulton proposed. Possibly because of this, Israel may have known about Fulton's book, although it was published some thirty years before.

Building construction fell off in the latter part of the 1830s and first half of the 1840s, as discussed in the previous chapter, and when construction revived, architects were more likely to recommend iron and brick, at least for the upper floors of fireproof buildings, than solid masonry construction. Iron and brick was now the state of the art fireproof building practice. The JFI carried an article "On the Construction of Fire-proof Buildings" in 1846, in which fireproof construction was defined as iron and brick construction. It announced the use of iron and brick for warehouses was "becoming universal" in Liverpool, the merchants of this city having been "burned into the conviction" that fireproof construction was necessary. The best practice building consisted of hollow columns, complicated cast iron girders in the shape of an arch with a curved top flange, and shallow brick arches secured with tie rods running between the girders.⁵¹

In the same year, 1846, John Notman, in his entry to the Smithsonian Institution building competition, proposed an iron and brick fireproof building like his Academy of Natural Science,

I propose to make the building thoroughly fire-proof throughout, by using cast iron beams and joists, filled in between them with brick work, constituting in fact a wall in

⁴⁹ Letter of R. W. Israel and others, December 14, 1832, to the Girard College committee in Philadelphia, Philadelphia Athenaeum, T. U. Walter collection, papers, box 8. Thanks to Bruce Laverty, Curator at the Athenaeum, for letting me know about the letter. The drawing is kept at the College.

⁵⁰ Robert Fulton, Treatise on ... Canal Navigation. Fulton's boxes were intended to be cast in segments of an arch. They were to be 4 feet wide by 12-15 feet long; they had sides 1 foot deep, 2 inches thick. The segments would be bolted to each other. Israel's boxes were to be 4 feet square, with 9 inch sides. Thanks to Gregory Dreicer for suggesting the Fulton book.

⁵¹ "On the Construction of Fire-proof Buildings," JFI vol. 11 3rd series (1846), pp. 153-157, from Glasgow Practical Mechanic and Engineering Magazine.

the floor -- a mode of building I carried out at the Academy of Natural Sciences in Philadelphia.⁵²

Also at this time, both Notman and Strickland proposed iron and brick construction for a fireproof building for the War and Navy Departments. The War and Navy building project was put off and the Smithsonian's Building Committee declined to build fireproof, because of the high cost. But a small, private fireproof library was built "at great cost" in Paterson, New Jersey, which had three cast iron girders.⁵³

While most designers were convinced of the superiority of the system compared with solid masonry construction, there were some hold-outs. For example, for the proposed War and Navy building, J. J. Abert, Chief of the U.S. Army Corps of Engineers, preferred iron and brick, but Robert Mills, who was among the architects invited to submit a design, cautioned against the system, arguing that the "merits of cast iron for this purpose are greatly overrated.... Its use in buildings has been recently condemned in England by Parliament....,"⁵⁴ even though Parliament had ordered just such a building for itself. Mills' chief objections were that the iron system cost more, and the expansion and contraction of iron at normal air temperatures was great enough to crack the building. But Mills was fairly alone in his judgment; the future was iron.

Increased Use of Iron Structurally in the U.S. in the 1840s

In the half decade, from about 1845 to 1850, iron began to be used to a greater extent structurally in American buildings. The herald of things to come was the iron column, which began to be used in the ground floors of "stores" -- the ubiquitous, multi-purpose "mercantile" building that began to crowd out residential buildings in city centers. Tenants of the valuable ground floors of these stores liked to have large window areas for displaying their wares. So the walls at the ground level began to be replaced with a structure of columns and lintels with glass filling the open spaces. This was possible because the front wall of building on a

⁵² Constance Greiff, John Notman, pp. 119-120.

⁵³ "Fire-proof Library," JFI vol. 12 3rd series (Nov., 1846), pp. 337-338. This library has been mentioned by several authors citing the JFI source, but no one has ever identified the building.

⁵⁴ "Fire-Proof Building for the War and Navy Departments," 29th Congress, 1st session, H.R. Executive Doc. No. 185, p. 23.

narrow city lot was not a bearing wall. Rather, the side, or party, walls carried the floor beams, so the front wall had to carry only itself. Early ground floors of this type were built with posts and lintels made of stone.

By the late 1830s, iron columns began to replace stone posts in the ground floor shop front in New York City.⁵⁵ In 1835, Ithiel Town designed what his one-time partner, Alexander Davis, described as the "first iron shop front in New York" for the Lyceum of Natural History.⁵⁶ Records of the construction of the building (1835-1836) show no payments for iron, so while the architect may have intended the front to be iron, probably it actually was masonry.⁵⁷ An inventor, Mr. Mott, in 1837 proposed that iron columns be used rather than stone in store fronts for the sake of fire safety; in an article containing an advertisement for his invention, he wrote that "columns have been erected in stores" in New York, but also noted that "some have declined using iron columns until they have been proved" fire resistant.⁵⁸ The new style of shop front began to spread to other cities. In Boston, where granite was abundant and had long been used to create open storefronts, iron posts began to appear in the 1840s. The architect and engineer George M. Dexter (1802-1872) used iron columns in this way in several stores he designed in Boston in the 1840s, and also used iron columns inside the buildings, none of which were fireproof.⁵⁹ Also at this time, the iron founder, Daniel D. Badger, introduced iron columns and lintels in the first story

⁵⁵ William J. Fryer, Jr., wrote that iron columns and lintels had been "long previously used" before the first complete iron front was erected there -- Bogardus' 1848 iron front. (Architectural Record vol. 1 (1891-92), p. 232.)

⁵⁶ Roger Newton, Town & Davis (New York: Columbia U. Press, 1942), pp. 63, 176, 184-85. I cannot locate the drawing Newton mentions. (Thanks to Deborah Kempe, Librarian at the Avery Architectural Library, Columbia University, for searching for it in Avery's collections.)

⁵⁷ Records of payments for development of the Lyceum building, 1834-1837, from the New York Academy of Sciences. Thanks to Rodney Nichols, Chief Executive Officer of the New York Academy of Sciences (formerly the Lyceum of Natural History of the City of New York). The Lyceum paid Town and Davis \$75 for plans. The building was on the west side of Broadway, at the corner of Prince (561-565 Broadway). The Lyceum sold it in 1844.

⁵⁸ Journal of the American Institute (1837), pp. 273-274.

⁵⁹ I looked through only a few portfolios of Dexter's drawings; the buildings I found with iron columns in the ground floor were the David Greenough store (1843), Jewett store (1845), Mass. General Hospital store (1844), Ashton & Sohien store, and Goodwin store. George Minot Dexter, drawings c. 1830s-40s, in the collection of the Boston Athenaeum.

of a building in Boston.⁶⁰ This was Badger's first essay in architectural iron, a line of business in which he became a leader in the following decade.

This innovation depended on technological progress in the foundry business -- the ability to make large hollow core items, like columns. American foundry art was advancing and some foundries cast large objects by the 1830s, for example cannons, but there is no definite evidence that they made columns on a commercial basis before the mid-1840s. An advertising circular from one of the country's largest foundries in this period, Cyrus Alger's South Boston Iron Company, listed thirty-five items it kept "on hand" including two types of "deck pipes," but not iron columns.⁶¹ Later in the century, old timers recalled that in the early years, cast iron columns -- as well as the pig iron used for making high quality castings -- were imported from England and Scotland.⁶² Solid iron columns of cruciform section, such as were first used in English mills, appear in the U.S. in the 1840s, though this does not prove they were imported.⁶³ The large increase in the use of cast iron columns after the mid-1840s date supports the idea that American foundries did not begin to manufacture columns until then.

The big turning point in the use of iron structurally occurred in 1850. U.S. pig iron production had increased in the 1840s, perhaps doubling by 1847 after falling in the first two years of the decade, while in 1851 and 1852, demand from that great sink for iron, rails for

⁶⁰ Badger's Illustrated Catalogue of Cast-Iron Architecture (New York: Dover Publications, Inc., 1981) reprint of 1865, p. 3. Badger gives the year as 1842.

⁶¹ Cyrus Alger, "List of Patterns, etc. etc. belonging to the South Boston Iron Company," Boston, 1836, pamphlet in M.I.T.'s Archives and Special Collections.

⁶² P. B. Wight thought the first cast iron columns used in the U.S. had been imported from Scotland. (AIA Proceedings, 1877.) At a meeting of the Polytechnic Club in New York in 1860, a Mr. Godwin commented that he had seen cast iron columns imported to the U.S. "a good many years." (Architects' and Mechanics' Journal vol. 2 (May 5, 1860), pp. 41-43). The author of a memoir of John B. Cornell, an important architectural iron manufacturer in New York, wrote that before Cornell's firms started up in 1847, "structural iron was nearly all imported from abroad." (Architectural Record vol. 1 (1891-92), p. 245.)

⁶³ The iron columns in the second story of the Main Arsenal at the U.S. Armory in Springfield, Massachusetts, built 1846-50, are cruciform in section, like early English columns. They measure 6 inches on one axis, and 5 inches on the other. The ground floor iron columns are hollow, tapered, and fluted. This building was designed as a warehouse for arms and is not fireproof.

the railroads, was being filled by imports for Britain.⁶⁴ Thus by mid-century, an abundance of domestic iron was available and began to be used for new purposes. The most solid evidence that something had changed -- both with respect to demand for iron products and in production capacity -- is that all at once, around 1850, a number of foundries began to specialize in the manufacture of structural iron.

These foundries, which soon became known as "architectural iron works," made columns but also almost simultaneously began to make an entirely new product, full building fronts of cast iron. In 1849-50, castings for building facades began to be manufactured in many cities, including Baltimore, New York, Philadelphia, and Trenton.⁶⁵ "We are now engaged in the construction of Iron houses," the rolling mill Reeves, Buck & Co., later Phoenix Iron Co., informed the U.S. Secretary of the Treasury in November of 1850, having heard that the government was about to contract for an iron custom house for San Francisco.⁶⁶ Two New York firms, Bogardus & Hoppin and Daniel Badger, also inquired about this job. This simultaneity is remarkable considering that any foundry's experience up to this time casting large structural pieces would have been slight to nonexistent. While the idea may seem simple enough -- essentially an extension upward of the iron ground floor storefront already in use -- it did present some novel problems, notably in the area of securely connecting the parts of the facade and fixing it to the rest of the building. Other sources of inspiration for the cast iron front came from iron structures made to be disassembled and shipped, which were known to some of the pioneers in the architectural iron industry.⁶⁷ The

⁶⁴ Peter Temin, Iron and Steel in Nineteenth Century America, pp. 20-21; Robert Jewett, "Solving the Puzzle of the First American Rail-Beam," Technology and Culture vol. 10 (1969), p. 382.

⁶⁵ The classic article on this subject is Turpin Bannister, "Bogardus Revisited; Part I: The Iron Fronts." On the beginning of the architectural iron industry in various cities, see James Dilts and Catharine Black, editors, Baltimore's Cast Iron; Ralph Chiumenti, Cast Iron Architecture in Philadelphia (Old City Civic Association of Philadelphia and Friends of Cast-Iron Architecture, New York, February, 1976); William J. Fryer, Jr., "A Review of the Development of Structural Iron," in A History of Real Estate, Building and Architecture in New York City (New York: Arno Press, 1967), reprint of 1898. Another overview of the development of cast iron buildings is Margot Gayle, introduction to Badger's Illustrated Catalogue of Cast Iron Architecture.

⁶⁶ Letter to Thomas Corwin, Nov. 15, 1850, Natl. Archives, RG 121, entry 26, "Letters Received."

⁶⁷ As early as the 1820s, Royal Engineers officers developed an iron frame for prefabricated hospitals and barracks in the West Indies, which was first used in 1827 and continued to be used into the 1840s. (John Weiler, "The Making of Collaborative Genius, Royal Engineers and Structural Iron 1820-1870," The Iron

pioneer (full) iron front buildings were James Bogardus' famous shop at Centre and Duane Streets, and the Milhau and Laing stores, in New York City (c. 1848-49); the Sun Building in Baltimore (1850-51), discussed below; and the Inquirer Building, Penn Mutual Building, and Brock Stores in Philadelphia, all of which were begun in 1850.⁶⁸ Architectural iron works made structural elements for buildings -- columns, box lintels, girders, joists, and iron ribs for domes -- in addition to facade panels, and also erected the structural iron. Although structural iron continued to have its critics, it became very popular. According to a participant and chronicler of the industry, "immediately ... the making of iron fronts rose into a business of magnitude and profit."⁶⁹

Buildings with iron facades, commonly called "cast iron architecture," are not the same as fireproof buildings; indeed, buildings with iron fronts rarely were fireproof. When iron fronts were first introduced, fire resistance was one of the advantages claimed for them. James Bogardus (1800-1874), one of the earliest and most prominent proponents of iron fronts, argued in his well-known treatise on cast iron buildings that they were "absolutely secure against fire" and that "cast-iron houses are perfectly fire-proof."⁷⁰ However, he recommended a building with an iron front and floors of iron or of wood protected with a noncombustible filling, which is presumably how his own building on Duane Street was

Revolution, p. 41. In 1839, William Fairbairn exhibited an iron flour mill built for export to Turkey. Fairbairn's building was exhibited before it was shipped and James Bogardus reportedly saw it on a visit to England. (James Dilts and Catharine Black, editors, Baltimore's Cast Iron, p. 6.)

⁶⁸ Dates of Bogardus' buildings from Turpin Bannister, "Bogardus Revisited; Part I: The Iron Fronts." Mr. Bannister concludes that since there were examples of iron used in facades before 1848, Bogardus can not take credit for being the "inventor" of the iron front. ("Bogardus Revisited; Part I," p. 16.) But as far as I can tell, Bogardus' fronts were the first full iron facades. The examples that predate Bogardus' first buildings of 1848-49 were either ground floor storefronts; a few prefabricated buildings; or iron decoration. So it seems fair to me to give Bogardus credit for realizing the first to multi-story, cast iron facade in the U.S., and possibly (as he himself believed) in the world. (Letter to New York Times, July 28, 1853; reference to the iron building sent to Cuba in 1841 is in a letter to New York Times, July 29, 1853.)

One of the key problems of a multi-story iron facade was the connections between the pieces. Bogardus' patent of 1850 (no. 7,337) concerns the method of constructing the frame, and what he claimed as his invention was "the method .. of making the frame work of iron houses of more than one story ...," not the idea of an iron front.

⁶⁹ William J. Fryer, Jr., ARABJ vol. 1 (April, 1869), p. 620.

⁷⁰ James Bogardus with John W. Thomson, Cast Iron Buildings: Their Construction and Advantages (New York, 1856), p. 5 and p. 12.

constructed. In fact, few of the iron front buildings constructed during the heyday of cast iron fronts, from the 1850s to the 1880s, were built this way. Save for the iron street facades, iron front buildings typically were ordinary buildings; the side (party) and rear walls were brick, and the floors and roof were framed in wood, without barriers. As such, they were no more fire resistant than any ordinary building with brick walls. The popularity of cast iron facades among building owners was not due to its fire resistance, but to the other advantages Bogardus claimed for them: they permitted large openings for windows; could be erected in all seasons and quickly, "by the most ignorant workman;" were thin compared with ordinary walls and consumed less floor area; and allowed for ornamentation.⁷¹ Many people nevertheless believed that any building with an iron front was fireproof. As the Chicago builder and building official Henry Ericsson described how people reacted when iron fronts first appeared in Chicago in the 1850s,

quarrymen, hewers of heavy timber, and lumbermen became panic stricken [thinking iron would quickly displace wood]. People just took it for granted that such iron buildings were fireproof. In the San Francisco fire of May 1851, people who took refuge in an iron building perished as it went up in flames....⁷²

One architect recalled how when several iron front buildings in New York burned "and the fronts fell down flat on their faces in the street, the average newspaper reporter was greatly nonplussed and befogged in his graphic descriptions, and wondered how iron buildings could be burned."⁷³ Although several of the fireproof buildings of the 1850s and 1860s did have iron facades, by the 1870s, iron fronts were rejected in favor of brick, terra cotta, or stone facing for the walls of truly fireproof buildings.⁷⁴ Thus, while they were an important product of the architectural iron foundry, and architectural iron foundries were the principal

⁷¹ James Bogardus with John W. Thomson, Cast Iron Buildings, quote p. 7.

⁷² Henry Ericsson, Sixty Years a Builder; the Autobiography of Henry Ericsson (New York: Arno Press, 1972) reprint of 1942, p. 184.

⁷³ Peter Wight, "Recent Fireproof Building in Chicago," IA vol. 5, extra number (April, 1885), p. 52.

⁷⁴ Did the fact that some iron fronts fell in fires prove that iron fronts were unsuitable for fireproof buildings? I have come across no reports of investigations of why any particular iron front fell. Some architects considered iron fronts cheap and vulgar, while many engineers had a prejudice against cast iron. Such people were glad for opportunities to denounce iron fronts and would not bother with details of the case. Very likely, falling fronts were the result of defective construction rather than the material.

contracts for the iron structures of fireproof buildings, cast iron fronts did not have much influence on the evolution of fireproof construction.

Another example of cast iron architecture that is often mentioned as having influenced the course of the use of iron structurally in buildings is New York's 1852-1853 exhibition hall, called the Crystal Palace after the London exhibition hall that was its model. Indeed this building contained an impressive amount of iron -- 1,800 tons of cast and wrought iron, which was used to make the ribs of the dome.⁷⁵ However, the building had no influence on the development of iron in buildings because the structural problems it solved (essentially, it was a giant roof) were so atypical.⁷⁶ Of the dozen or so companies that supplied castings for this building, only one became a prominent architectural iron foundry.⁷⁷

The Brief Phase of Cast Iron Fireproof Buildings

The most common style of fireproof building in Britain in the first half of the nineteenth century, the iron and brick cotton mill, was the model for the American fireproof building. However, as discussed above, the simple cast girder, post, and brick arch system filled a room with columns and was not appropriate when a design called for large clear spans. For this reason, most likely, American architects used a combination iron girder and joist type of construction -- replicating wood floor framing -- in iron, with brick or some other incombustible material filling between the joists, in their very first essays in iron and brick fireproof construction. Most of the men who designed these fireproof buildings were born in the U.S. and were self-educated in technical matters. They probably learned about the

⁷⁵ The ribs are described in a newspaper article as being made of two pieces of curved angle iron, in two rows connected by trellis-work. (New York Times, July 15, 1853, p. 2.)

⁷⁶ With one exception: it may have influenced the design of the new dome of the U.S. Capitol, which Congress authorized in 1855.

⁷⁷ Jackson's firm -- presumably Jackson Architectural Iron Works, which was still in business at the end of the century -- became a prominent architectural iron company. Only one other, Hogg & Delamater, bid on iron work for federal buildings in New York in the 1850s and 1860s, that I have found. (Hogg & Delamater offered to build an iron facade for the Assay Office. Letter from Alexander Bowman to James Guthrie, October 7, 1853, National Archives, RG 121, entry 26, New York Assay Office.) The firms that bid on federal government work became active iron contractors for buildings in New York and elsewhere.

iron and brick system from books although there were no textbooks, as yet, on the system. Designers also relied on the "practical" men at the mills and foundries for advice on design of structural members, methods of connecting posts and beams, and framing plans.

For ten years, between about 1845, when the first iron and brick fireproof buildings began to be built in the U.S., and 1855, when wrought iron beams became more available from two domestic mills, iron frames were made of cast iron. The national government turned to this system of construction for its buildings, both in Washington and elsewhere. They are transitional, in the sense that they combine masonry vaults with iron and brick segmental arches.

One early example is the Winder Building at 17th and F Streets in Washington, which dates from 1847-48. This building was constructed by a private owner for the use of federal agencies and consequently was built fireproof with state-of-the-art technology.⁷⁸ A corridor running between offices on the ground floor is roofed with barrel vaults resting on interior walls. The floors over the ground level offices are made of cast iron beams, running between the inside corridor wall and the outside wall of the building, filled in between with shallow brick arches tied with iron rods and turnbuckles.⁷⁹ The floors were paved with brick and stone; the staircases were iron. It was heated by a furnace rather than dangerous open fireplaces -- a novel system that confounded many of the tenants.

The fireproof Congressional Library, built to replace the one that burned in a fire on December 24, 1851, is another example. The library at this time was a room inside the center block Capitol. Thomas Walter, who had been selected to build an extension to the U.S. Capitol and was on hand in Washington, designed and superintended the construction of the new library room. The main library room was 91 by 34 feet; it was lined with three

⁷⁸ "Report, Commission on Public Buildings and Grounds," HR No. 102, 32nd Congress 1st session (serial set no. 656). See also National Park Service, Historic American Building Survey, DC-392, collection of the Library of Congress. HABS lists the architect as Richard Gilpin. The government eventually bought the building, in about 1854.

⁷⁹ Remarkably, the beam soffits, arches, tie rods, and other details are visible today in this building. I inspected what could be seen in the entry in January, 1995; I did not have clearance to look beyond this area.

stepped-back tiers of iron book cases, the lower ones forming a floor for the upper ones. His 1852 specifications called for these floors to be half-inch thick cast iron plates; the ceiling was iron and glass, suspended from iron trusses (which were the roof frame) and also supported by huge, ornamental iron brackets. The exterior of the roof was covered with copper, with a long skylight over the glass panels in the ceiling.⁸⁰ This unusual project was executed by the New York foundry, Janes, Beebe & Co., who won the contract for the iron work and the roof, including manufacture, delivery, and construction, and also finished and painted the interior. Interestingly, this foundry was already working in Washington, as it had a contract to supply the heating system for the east wing of the Patent Office, which was being completed when the library project came up.⁸¹ Walter finished the east wing of the Patent Office in the vaulted style, but designed the library room in iron. He was proud of its novelty,

The whole of this immense iron room will therefore have been cast, fitted, and put up in less than six months; and as far as my own knowledge goes, it is the first room ever made exclusively of iron.

The project was complete in the summer of 1853.⁸²

Another example is the original building of the Smithsonian Institution, better known as the Castle, also in Washington. The architects invited in 1846 to submit proposals for the building all recommended some kind of structural fire protection for the building. Robert

⁸⁰ "Specifications for the Iron Work for the Repairs of the Interior of the Congressional Library," May 8, 1852, T. U. Walter collection, papers, Philadelphia Athenaeum, box 13. A drawing of this room can be found in William C. Allen, The Dome of the U.S. Capitol: An Architectural History (Washington: U.S. GPO, 1992), p. 9.

⁸¹ Report of the Architect of the Extension of the Capitol, Message from the President, House Executive Document No. 60, Feb. 12, 1852 (serial set no. 641).

⁸² While the room is gone, an echo of it can be found in the extant State Department library -- with cast iron galleries supported by large, decorated brackets, and covered with a skylight -- in the 1871-1886 State, War, and Navy Building (now Old Executive Office Building) in Washington. The library of the contemporaneous Peabody Institute in Baltimore (1872-1874), with a cast iron interior and sheet metal book shelves, is another room modeled on Walter's library. (Ferdinand C. Latrobe, Iron Men and Their Dogs (Baltimore: Ivan Drechsler, 1941), pp. 53 and 55.)

Dale Owen, a member of the Building Committee, considered the relative cost of the groined arching and iron beams with arches methods and concluded that cost of the two methods was roughly comparable. Nevertheless, both types of construction were deemed too expensive and in the end the Regents authorized wooden construction for most of the building. The imposing-looking, stone Castle rose between 1847 and 1850, most of the interior of which was wood and plaster. Only sections of the basement level -- to contain the furnaces, janitor's rooms, and storage for Smithsonian's personal effects -- were to be vaulted. In the rest of the building, the fire protection measures consisted of a ceiling covered with two inches of cement under the roof, and a deafening layer of lime, clay and sand on the wood floors.⁸³ On top of this, the floors of many rooms were paved with flag stones.

Possibly the wood floors could not bear all this weight, but in any event, in February, 1850, the center section of the building which was to contain the main hall -- the last part to be built -- collapsed. The Board of Regents resolved to rebuild it in a substantial, fireproof manner and it was reconstructed between the summer of 1853 and 1855. The central block was gutted, down to the foundations. The basement level was roofed with masonry vaults; a passage through the center was formed of cast iron beams and brick arches (the bottom of these beams, which are asymmetrical in section, are visible in the basement).⁸⁴ The second floor, covering a large central room, was made of iron with brick arches. The wings were not rebuilt; moreover, the roof over the central block was built in wood and, in conformance with Murphy's law, caught fire some ten years later. This work was designed and superintended by the U.S. Army Corps of Engineers officer Barton S. Alexander (1819-1878) as the original architect of the building, James Renwick, had resigned.⁸⁵ Alexander seems to have made a

⁸³ Robert Dale Owen, Hints on Public Architecture (New York: DaCapo Press, 1978) reprint of 1849, p. 107.

⁸⁴ The lower flange of the beams measures about 10 inches; the dimension of the top flange is unknown.

⁸⁵ "Report of the Building Committee," Annual Report of the Board of Regents of the Smithsonian Institution for the year 1853, pp. 67-69. Information on the history of this building comes from the Annual Reports, 1849-1854, and Robert Esau, "Fear of Fire; An Investigation into the Fireproofing of the Smithsonian Institution Building c. 1846-1890,"

specialty of buildings, as he had built several buildings at the Military Academy itself and was in Washington at the time of his appointment to the Smithsonian job in order to build the Military Asylum (Soldiers' Home) (1851-53) there. His aesthetic sensibility reflected his military background; as he described the central hall, "There is not much ornament, but still enough, as I think, to enable the building to do its duty with grace and dignity."⁸⁶ Despite his efforts to economize, the final cost of the work exceeded his estimates.

Outside of Washington, site work began for a fireproof custom house in San Francisco in 1852. Thomas Walter's specifications of 1851 called for a solid masonry ground floor, but the ceilings of all rooms and passages of the attic story, except for the collector's room, were to be of brick arches springing from cast iron joists and an iron skewback in the wall.⁸⁷ The building took so long to construct that Walter's specifications probably were not followed. Rather, the architect Gridley J. F. Bryant (1816-1899) was appointed the "referee," and all the parts of the building were manufactured in the east and shipped to local builders. The iron work was made in Boston by the safe and vault manufacturers Smith, Felton & Co., who were among the few fireproof building contractors in New England, according to Bryant's designs. Bryant had worked with Parris at the Navy Yard when Parris built the iron and brick arched floors over the engines in the ropewalk, so probably had first hand experience with this system of construction.⁸⁸

State and local government buildings also began to be built in iron and brick. In 1848, a Baltimore foundry, Hayward, Bartlett & Co., was awarded the contract to make cast iron joists or girders for the fireproof South Carolina State House in Columbia.⁸⁹ In 1853, Leopold Eidlitz's (1823-1908) design for a partly fireproof City Hall for Springfield,

Smithsonian Institution, August 10, 1990.

⁸⁶ "Report of the Building Committee," Annual Report of the Board of Regents of the Smithsonian Institution for the year 1854, p. 71.

⁸⁷ "Specifications for a Custom-House to be built at San Francisco, California," March 22, 1851, National Archives, RG 121, entry 26, San Francisco custom house.

⁸⁸ Edwin Bearss, Historic Resource Study, Charlestown Navy Yard, vol. 2, p. 768.

⁸⁹ Ferdinand Latrobe, Iron Men.

Massachusetts, was approved. The offices of the Clerk and Treasurer were fireproof; iron girders were used in the first floor and in the roof frame.⁹⁰ While he was serving as referee for the San Francisco custom house, Gridley J. F. Bryant designed and built a fireproof addition to the rear of Massachusetts' state house (1853-54), which contained the state library. This addition was mostly vaulted, but the third floor and roof of the side rooms had iron beams and brick segmental arches. The beams undoubtedly were cast iron.⁹¹

With the introduction of the iron and brick system, private owners began to build fireproof buildings to a much greater extent. A new kind of building began to appear in cities, the "office building." Companies that had valuable machinery and equipment, such as publishing or printing firms with steam presses and telegraph offices, sometimes built fireproof buildings for their own use and to rent. For example, when the publisher of the Baltimore Sun decided in 1849 to build a new structure, which was occupied by telegraph offices in addition to his printing and publishing operations, he wanted a fireproof building. The resulting Sun "Iron Building" (1850-51) had cast iron fronts on two sides and an interior framework of cast iron posts and girders. The floors were framed in wood, but were covered with iron plates rather than boards, then a layer of mortar as an additional fire barrier, and finally a wood finish surface.⁹² Two Baltimore foundries supplied the structural iron for the building -- the firms of Adam Denmead & Sons and Benjamin S. Benson -- and the windows on the ground floor were protected with patent rolling iron shutters from Daniel Badger's foundry in New York City.⁹³ This very expensive building was designed by Bogardus and the architect Robert G. Hatfield (1815-1879), who went on to become a well-known specialist in the technical aspects of building construction. The Sun building contained several large

⁹⁰ Exercises at the Dedication of the New City Hall, January 1, 1856, (Springfield, 1856).

⁹¹ The Capitol of Massachusetts Showing the Enlargement Erected in 1853 & 54, portfolio of architectural plans, in the Fine Arts Department of the Boston Public Library.

⁹² David G. Wright, "The Sun Iron Building," in J. Dilts and C. Black, editors, Baltimore's Cast-Iron Buildings.

⁹³ David G. Wright, "The Sun Iron Building," in J. Dilts and C. Black, editors, Baltimore's Cast-Iron Buildings, p. 26.

Hoe rotary presses and a stereotype foundry for the newspaper. Much of the space on the second floor was rented to three different telegraph companies, a great convenience for the newspaper.⁹⁴

Other fireproof buildings constructed by private owners are known from the catalogue of the prominent New York iron founder, Daniel D. Badger (1806-1884).⁹⁵ Badger's Architectural Ironworks manufactured structural iron and its iron fronts were shipped to cities around the country, but only a fraction of these buildings were fireproof. For example, by 1865, Badger's firm had delivered a 850 feet of cast iron building fronts to Chicago.⁹⁶ The firm's most notable projects there were iron front buildings lining opposite sides of Lake Street, between State and Wabash Streets; each side looked like the front of one large building, but actually there were four separate stores on each side of the street.⁹⁷ These were the cast iron Lake Street stores that, according to Henry Ericsson, so unnerved the city's lumber yard owners, which the owners thought of as "fireproof." While the details of construction are scant, it seems that none were actually fireproof.

Perhaps the most thoroughly fireproof of Badger's projects up to 1865 was the building for I. M. Singer & Co., manufacturer of sewing machines, on Mott Street in New York. As described in the catalogue, "This building is perfectly fire-proof; the roof, the front and rear, including sashes, shutters, &c., being entirely of iron. The floors are supported upon iron columns and girders, with iron beams and brick arches. The stairs, &c., are of iron...."⁹⁸ The building was designed by Badger's chief designer, George H. Johnson (1820-

⁹⁴ David G. Wright, "The Sun Iron Building," in J. Dilts and C. Black, editors, Baltimore's Cast-Iron Buildings, p. 28.

⁹⁵ Badger's Illustrated Catalogue.

⁹⁶ Badger's Illustrated Catalogue, list of projects in Chicago.

⁹⁷ According to Ericsson, John M. Van Osdel's account books indicate that he designed the buildings and Badger furnished the fronts. Badger's 1865 catalogue also lists these fronts. The buildings were constructed about 1856. (Henry Ericsson, Sixty Years a Builder, pp. 151-154.)

⁹⁸ Badger's Illustrated Catalogue, p. 10.

1879).⁹⁹

By the early 1850s, iron had replaced masonry vaults as the preferred material for fireproof construction, however the details of building in iron were not standardized. Architects improvised various methods of building fireproof. This can be seen in the entries to an 1855 competition for a new "completely and absolutely fireproof" library for the city of Boston. Edward and J. C. Cabot's proposal had floors made of (probably wrought) iron beams and stone slabs, in the architects' words, "plate-iron girders, carrying slate panels, and supporting wire-gause furring for the ceiling below." John R. Hall proposed a building in which the upper floors were made of cast iron joists and iron plates. The winning design was by Charles Kirby and a drawing dated 1863 (after the building was completed) shows symmetrical, I shaped cast iron beams;¹⁰⁰ however, the floors apparently were not built as shown in the plan. An engineer who saw the building being demolished in 1899 reported that it was constructed with cast iron girders of inverted "deck beam form" -- a T shaped beam -- sixteen inches deep. These were spaced 10 feet on center and carried inverted Y shaped joists, about 9 inches deep and spaced four feet on centers, from which sprang brick segmental arches. This type of framing that had been used in England in the 1840s.¹⁰¹ The iron for this type of floor construction could be ordered from Badger's Architectural Ironworks; a Y shaped "vault beam," so called because the angled web was designed to start a brick vault, was illustrated in his 1865 catalogue.¹⁰² (Illustration 3-4.)

But a strong force for standardization emerged in the second half of the decade, and this was the federal government. Beginning in the early 1850s, the government commenced a

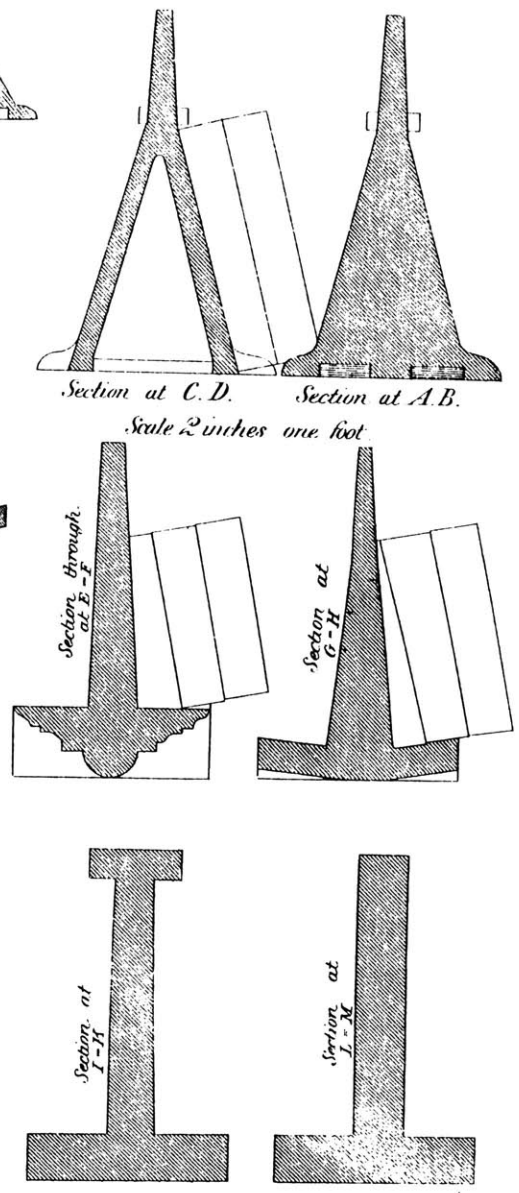
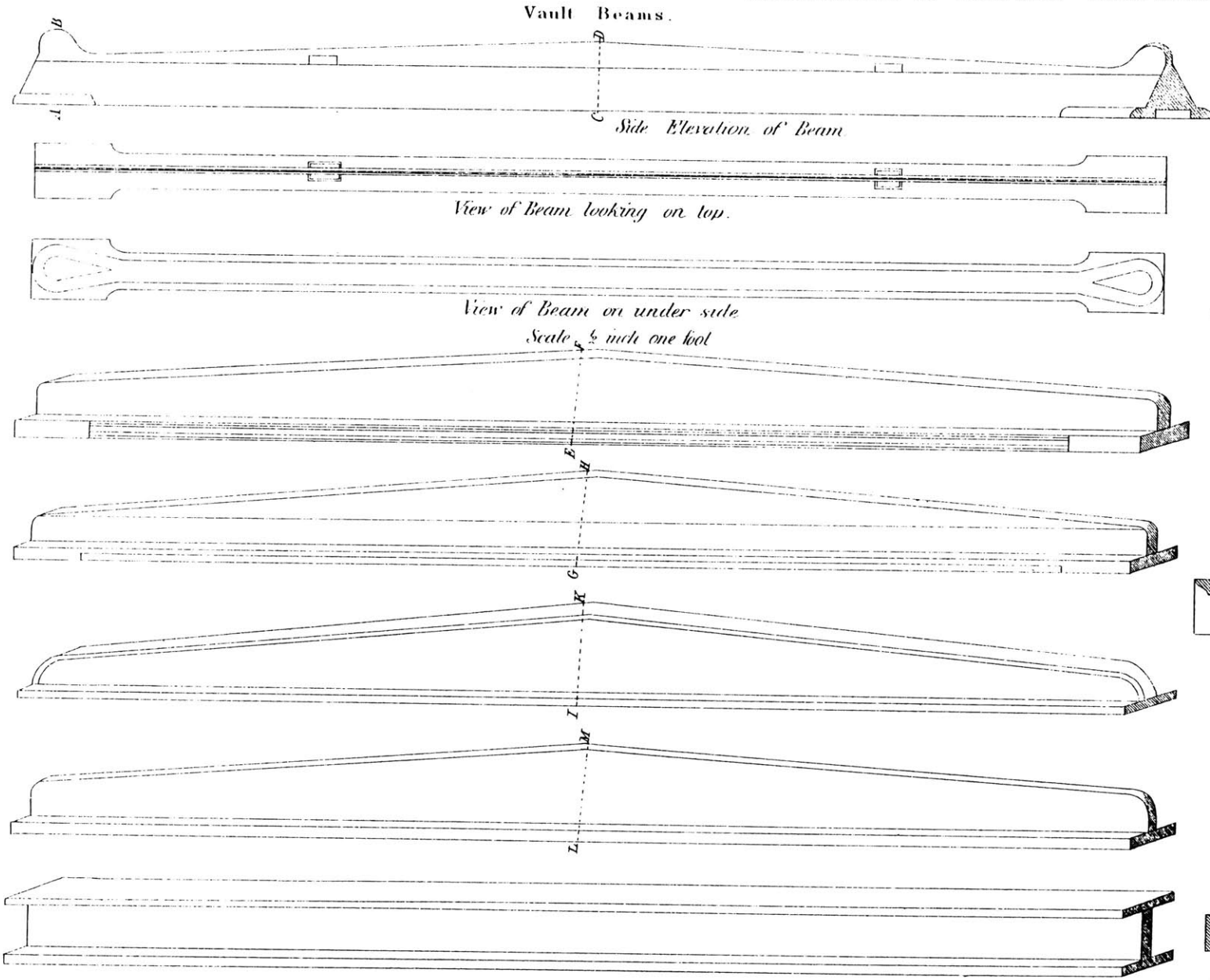
⁹⁹ Badger's Illustrated Catalogue.

¹⁰⁰ Boston Public Library competition entries are in the Proposals and Plans for the Boston Public Library, 1855, Boston Public Library, Print Department.

¹⁰¹ Joseph K. Freitag, "Steel Buildings and Our Steel Industry," Fireproof Magazine vol. 3 (October, 1903), p. 35. This particular form of floor framing, the T girder and Y joist, was used by David Mocatta for the 1841 West London Synagogue. (Robert Thorne, editor, The Iron Revolution, plate on p. 4.)

¹⁰² Badger's Illustrated Catalogue, plate 53.

Illustration 3-4. Cast iron "vault beams."



Scale of Section $1\frac{1}{2}$ inches one foot.

program for constructing an unprecedented number of public, civilian buildings: roughly 70 new public buildings were authorized by Congress in this decade. Congress also required that the buildings (with the exception of a few small buildings in frontier areas) be fireproof. The Treasury Department was responsible for building these structures. Just at this time the iron and brick system of fireproof construction was coming into use, and this was the system -- not the vault system -- that was adopted for the new federal buildings. The Treasury Secretary decided that, to carry out the provisions of the appropriations acts, the new buildings would be built with "Brick walls, Rolled Iron Beams, Iron Roof & c."¹⁰³ Not only did the Treasury Department construct many buildings -- by the end of the 1850s, practically every U.S. town of respectable size had a new fireproof federal building -- but it built them in a consistent way, with the structural (as well as facade) plans coming from Washington. Thus, any builder or designer wishing to learn how to build a fireproof structure had only to observe the construction of the federal office in their city. Federal buildings designed in the vault system that were already under construction when the office was established, for example the custom house in New Orleans, were completed with in the iron and brick style.

The Office of Construction of the U. S. Treasury Department in the 1850s

The huge public construction program in the 1850s probably resulted from several factors: the spread of settlements across the nation; the need to replace small, out-dated buildings in growing cities in the East; and a flush treasury. Federal receipts jumped by more than a third between 1849 and 1850 and increased another 20 percent in 1851, principally due to growth in customs revenues.¹⁰⁴ Congressmen developed a taste for pork. Every new civil building was individually authorized by a Congressional act and Congressmen began to vote for them at a great rate. By 1853, seventeen custom houses and five marine hospitals were under construction, plus an Assay Office in New York City -- urgently needed for

¹⁰³ Ammi Young to Alexander Bowman, letter dated Oct. 9, 1853, National Archives, RG 121, entry 6, "Letters Sent, Chiefly by the Supervising Architect."

¹⁰⁴ U.S. Dept. of Commerce, Bureau of the Census, Historical Statistics of the United States (Washington, DC, 1975), series Y 352-357, p. 1106.

storing and refining gold flooding in from California. In the first session in 1854, Congress voted for sixteen more custom houses and six marine hospitals, to be built in as many different cities, from Belfast, Maine, to Galveston, Texas, to Burlington, Iowa.¹⁰⁵ It is possible to learn a great deal about these buildings from construction records preserved in the National Archives in Washington.¹⁰⁶

Most of the nation's civil offices -- custom houses and warehouses, mints, and marine hospitals (marine hospitals were not for enlisted men, but for merchant seamen, who contributed to the expenses of running the hospitals¹⁰⁷) -- were part of the Treasury Department. In addition, the Treasury Department was given the responsibility for constructing or acquiring buildings for virtually all civilian purposes, including post offices and federal court houses. In the early 1850s, the new architect of the Treasury, Ammi Burnham Young, urged that the iron and brick system be used for these buildings instead of vaults.¹⁰⁸

Young's first large iron and brick fireproof federal buildings, like the others of this type built in the 1840s and first years of the 1850s, had cast iron columns and beams and brick arched floors. An example is the Cincinnati Custom House, built at the corner of 4th and Vine Streets. Inside the walls of a classical temple designed by local architects, Young inserted a state-of-the-art fireproof framing system. His 1852 specifications called for cast

¹⁰⁵ Bowman to James Guthrie, Report on status of projects underway, November 24, 1854, National Archives, RG 121, entry 6.

¹⁰⁶ National Archives, Records of the Public Building Service, RG 121.

¹⁰⁷ The rest came from Congressional appropriations. "Reports of the Secretary of the Treasury on the State of Finances," Executive Documents, 33rd Congress, 1st Session, vol. 4 (1853-54), p. 20.

¹⁰⁸ Some writers believe that Young was given the position that Robert Mills had held, but this is not the case. Young became a salaried employee of the Treasury Department and worked on Treasury Department buildings exclusively. Mills, on the other hand, received commissions, from the Treasury, for example, for which he received fees. He also worked on the Patent Office and U. S. Capitol, which were not under the control of Treasury. Rather, Thomas U. Walter, who worked on the extensions to the Patent Office and Post Office, projects Mills had started, was Mills' replacement.

iron columns, iron girders and beams, and brick arches, the tops of which were to be filled with concrete made of "cement mortar, brickbats, coarse gravel, &c."¹⁰⁹ The building contained almost no wood and much iron: the stairways, cornice and balustrade, window and door frames, capitals and bases of antae, balcony, skew-backs for the arches, thresholds, and shutters were to be iron. Despite the novel materials and construction methods, the building had a traditional appearance and plan. (Illustration 3-5.) Another early example of an iron and brick federal building is the Charleston Custom House, built from plans made by Young in 1850. This "Roman Corinthian" custom house combined ground floor vaults and upper floors constructed of "iron girders and brick arches;" the roofs were to be "most probably of metal."¹¹⁰ Other government buildings that Young worked on in 1852 and 1853, which were originally designed to have cast iron beams and girders, were the custom houses in Bath, Maine; Mobile, Alabama; and Wilmington, Delaware.¹¹¹

The construction records for the Cincinnati Custom House illuminate the advantages and disadvantages of the system. A key advantage, compared with the vault system, was cost. Iron was expensive, but so were stone and good bricks, which at the time were made by hand. For example, one builder who offered to construct the building either vaulted or of iron and brick, bid \$169,000 for a stone building and \$138,000 for an iron one. The actual

¹⁰⁹ National Archives, RG 121, entry 26, Cincinnati custom house, box 179.

¹¹⁰ "Report by E. B. White, Jan. 1, 1853," National Archives, RG 121, entry 26, Charleston custom house, box 133. Among the iron contractors who supplied iron to this building in the 1850s were Hayward, Bartlett & Co., who made the interior cast iron railings and posts, and Daniel Badger, who supplied columns for the rotunda. A local Charleston firm, C. Werner, supplied the iron window and door frames and shutters.

Edward White, who graduated from West Point a year after Alexander Bowman, superintended the construction of this building. He resigned from the military in 1836 and worked as an architect and engineer in Charleston until the Civil War, when he fought against the U.S.

¹¹¹ The drawings for these buildings, contained in "Plans of Public Buildings in the Course of Construction Under Direction of the Secretary of the Treasury," show cast iron beams: Bath Custom House, January 1853; Mobile Custom House, Oct. 22, 1852; Wilmington Custom House, Feb. 12, 1853. Sets of these drawings are available in the National Archives, Library of Congress, and a number of other libraries, including the Boston Public Library. The drawings are lithographs, prepared as bid documents.

Illustration 3-5. Cincinnati Custom House and Post Office.



Post Office Department
Office of Special Agent.

Cincinnati, O. March 12 1872

Please return this, with your reply.

cost of this custom house came to about \$132,000; the great quantity of iron in this building amounted to 29 per cent of the total cost, while the cut stone, for the walls, came to 31 per cent.¹¹² A disadvantage of the system, on the other hand, was that there were not many firms who could execute the contracts for this building. Only one firm submitted a complete bid for the iron work; likewise, one bid was received for the tin roof, and one for the brick work. But even though the number of firms that could execute these contracts apparently was limited, the necessary material could be procured, and from Cincinnati men. In fact, the company that was awarded the iron contract was a local Cincinnati foundry, Horton & Macy. What the source of this firm's expertise was, I can not say; it is remarkable that a local company could fulfill a contract that included 52 girders and 66 beams ranging from 1 to 1 1/2 feet deep.¹¹³ From the construction reports, it seems that the various trades encountered no technical problems erecting this building; nevertheless, it was not completed until 1857. As with so many government buildings, there were disagreements between the superintendent and the tradesmen, charges of incompetence, favoritism, and disloyalty. The specifications

¹¹² National Archives, RG 121, entry 26, Cincinnati custom house, box 179.

¹¹³ Did Horton & Macy actually do the casting? There is no indication in the construction records that they did not. (National Archives, RG 121, entry 26, Cincinnati custom house.)

for the building show that Young was acquainted with the English best practice. As shown in 1855 drawings, the cast iron beams are the asymmetrical section recommended by Hodgkinson. Young also required that the girders and beams be "tried and proved" before using, as English architects commonly did.¹¹⁴

While the Treasury had adopted a new system of fireproof construction, its method of getting buildings constructed was unsuited to the volume of new construction for which it was now responsible. Before the arrival of Treasury Secretary James Guthrie in 1853, the usual method of constructing buildings was for the Treasury department to hire private architects to furnish plans and select a committee of local men, with the right political inclinations, to oversee the construction. This system put too much reliance on the faithfulness of private individuals to see that the building was constructed properly and within budget. The government could control the process only through close monitoring, which it could not do -- considering the large number of buildings Congress was authorizing -- without greatly increasing the size of the staff. To get better control, James Guthrie, whom Franklin Pierce appointed Secretary of the Treasury when he took office in 1853, changed the process. He centralized certain functions -- building design, contractor selection, and financial management -- and made them the duties of salaried employees. He ended the practice of assigning (in other words, selling) contracts and standardized reporting and disbursement procedures at the far-flung job sites. The new office was called the Construction Branch or the Office of Construction. To oversee the newly established central office, he sought a "scientific and practical engineer" and applied to the Secretary of War for such a man.¹¹⁵

¹¹⁴ National Archives, RG 121, entry 26, Cincinnati custom house, "Specifications for the Custom-House...at Cincinnati, Ohio," 1852: "All the girders of the first and second story flooring must be tried and proved before using, by the application of 35,000 pounds, and those of the attic flooring by 22,000 pounds to their centre, their ends being supported, which must in no case cause a deflection therein at the centre of more than 3/8 of an inch. The beams are to be proved in the same way...." On British practice, see R. J. M. Sutherland, "The Age of Cast Iron 1780-1850: Who Sized the Beams?," p. 30 and Lawrance Hurst, "The Age of Fireproof Flooring," The Iron Revolution (1990), p. 39.

¹¹⁵ "Reports of the Secretary of the Treasury on the State of Finances," H. Doc. 3, 33rd Congress, 1st session (1853-54), p. 19.

Corps of Engineers officers, trained to construct military supply routes and fortifications, were involved in a variety of private construction projects, beginning in 1824 with the General Survey Act. The grandiose plans and disdain for economy, under the influence of the French engineering tradition, combined with the primitive state of engineering science in the early decades of the century, led to a number of costly and unsuccessful public works projects in the early decades of the century.¹¹⁶ But the hostility to professional engineers had abated by the middle of the century, coincident with the increasing complexity of engineering projects,¹¹⁷ and while its officers may have been considered extravagant, they also were considered "above suspicion in money matters."¹¹⁸ At the time of the Secretary's application, several Corps officers were working on civil (non-military) public buildings. One, Barton S. Alexander, previously mentioned, was superintending the construction of the Smithsonian building in Washington. Another, Montgomery Meigs, was appointed in April, 1853, to handle the finances for the extension of the U.S. Capitol. A third, P. G. T. Beauregard, was appointed, also in 1853, to superintend construction of a new (the third!) custom house in New Orleans. And a fourth, William B. Franklin, superintended the construction of the custom house and marine hospital in Portland, Maine, from 1855-1857.

An interesting aspect of the Secretary's application is that he wanted a man who was both scientific and practical -- qualities that were usually considered antithetical. Scientific engineers had reputations for being theoretical and indifferent to cost, while practical engineers were considered cost conscious but lacking education in theory of structures and materials. Nevertheless, in Alexander Hamilton Bowman (1803-1865), the Secretary got a man who combined both qualities. Bowman, with the rank Captain, had been a civil engineer with the Army since graduating from West Point in 1825; his projects included river

¹¹⁶ Todd Shallat, "Science and the Grand Design: Origins of the U.S. Army Corps of Engineers," Construction History vol. 10 (1994), pp. 17-27.

¹¹⁷ Daniel Calhoun, The American Civil Engineer (Cambridge: M.I.T. Press, 1960).

¹¹⁸ A. J. Bloor, in Minutes, A.I.A. Board meeting, August 16, 1877. Manuscript in library of A.I.A. in Washington, D.C.

improvements, road construction, and fortifications, principally in South Carolina, where he was working just before his appointment.¹¹⁹ He was assigned the post Engineer-in-Charge and began working for the Department in the fall of 1853.

The work of the office was divided between Bowman, who headed the office, and the Supervising Architect, a post held by Ammi Young. Young had been working for the Treasury in Washington since 1852 and apparently his politics did not disqualify him to continue in the new administration. Bowman managed the development process overall, from review of sites to communications with Congress concerning progress and finances. Young's duties were "to make all the designs, plans, and working drawings of all the Buildings being erected under the direction of the Secretary of the Treasury," as well as construction specifications.¹²⁰ They were assisted by draftsmen and clerks in the central office in Washington, and by site selection committees, construction superintendents, and disbursing agents at the project sites.

The procedures and policies Bowman set for developing public buildings are remarkably like the recommended practices for public bidding and construction today. He required public bidding and sealed bids, written contracts, performance bonds, regular progress reports from site superintendents, regular financial reports from the disbursing agents, and verifications that the work performed corresponded to specifications and prices in the contracts. His "regulations for the construction of custom houses and other buildings" were sent to all construction superintendents, and extant records show that compliance with reporting requirements, at least, was very good.¹²¹

While the rationale for centralizing the office was to control the cost and quicken the pace of new construction, the effect of having all designs and specifications issued by one office, under the direction of one architect and one engineer, for a limited number of kinds of

¹¹⁹ George Cullum, Biographical Register of the Officers...of the U.S. Military Academy at West Point, N.Y. vol. 1 (Boston: Houghton, Mifflin & Co., 1891) 3rd edition.

¹²⁰ Young letter Oct. 26, 1852, National Archives, Record Group 121, entry 6.

¹²¹ The regulations are printed in Report of the Secretary of the Treasury on the State of Finances, H. Doc. 3, 33rd Congress, 1st session (1853-54), pp. 278-284.

buildings, was that fairly uniform designs and specifications evolved for the several building types. Each of the building types looked very similar on the outside; for example, one design was used for the custom house-post office-federal court house structures and another for marine hospitals. The standard models were enlarged or shrunk depending on the amount of space required at a particular location, and ornamentation varied slightly.

Even more uniform than the exteriors were the materials and methods of construction. The construction specifications that had evolved by 1855 were applied to all the fireproof Treasury buildings. The standard building had cast or wrought iron girders; wrought iron beams; floors of shallow brick arches, tied with iron rods that ran between the beams (hooking over the top flange); and an iron roof with a frame made of wrought and cast iron, covered with corrugated iron. By the example of its buildings; its tests of materials and maintenance of a sample room; its steady patronage of iron manufacturers, which gave them experience with such construction; its publications and distribution of plans and details of the new fireproof buildings, the federal government became an important agent of diffusion and helped establish its model as the standard for fireproof construction in this period.

The Federal Government Adopts Wrought Iron Beams

Just as the number of government buildings authorized was increasing tremendously, solid, wrought iron beams of American manufacture came on the market. They were commonly called "solid" because they were a single rolled piece. These beams were rolled on mills like those used for making rails; the process was the same, only the shape of the dies differed. While wrought iron beams made from plates and channels were made England, there is no concrete evidence that any were imported before American rolled beams became available. Nor were the solid rolled French beams of the time, which were much smaller and lighter than American beams, imported. In other words, since iron beams were only used in fireproof buildings, until iron framed buildings became popular there was no reason to import foreign beams. But when they did become popular, not coincidentally, American rolled beams were available. Foreign rolled beams were eventually imported, once the iron and brick system became established.

The iron and brick system was still quite new to the U.S. when wrought iron beams were introduced. American designers quickly adopted them in place of cast iron.

Consequently, American iron and brick fireproof buildings, almost from the beginning, were different from the British fireproof mills, in which cast iron continued to be used for beams until the end of the century. In the U.S., the switch to wrought iron was thorough: government buildings that were designed to have cast iron beams were built with wrought iron and some that were under construction were completed with wrought iron beams.

That wrought and cast iron were dissimilar materials was not generally appreciated, even though spanning members made of both materials were in use both in England and France. As mentioned above, the different performance of cast and wrought iron railroad rails showed that the properties of the material were quite dissimilar, but no experiments comparable to the ones made by to determine the strongest section for cast iron had been made for wrought iron.¹²² Experiments on wrought iron structural members conducted in the 1840s in connection with the design for two railroad bridges in Wales -- the Britannia and the Conway -- proved that wrought iron was far superior to cast iron in tension. Formulas were developed from the experimental results which guided design of structural work. However, the formulas were empirical.

These and other results of tests of materials were compiled by Fairbairn in his book, On the Application of Cast and Wrought Iron to Building Purposes, published in 1854 both in London and New York. Fairbairn by no means rejected cast iron for beams but encouraged the use of wrought iron because he felt it was generally safer and stronger than cast iron, concluding that wrought iron, "appears to me to be in every respect adapted to the construction of fire-proof buildings."¹²³ He discussed wrought iron as if it was an entirely new material, seemingly unaware that wrought iron beams were already used to a large extent in building construction in Great Britain -- for example, in the iron and concrete fireproof Fox and Barrett floor. He also apparently did not know that one piece, "solid," beams were being

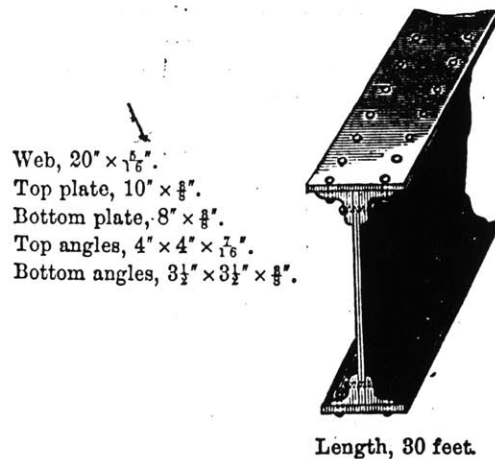
¹²² For example, Peter Barlow discusses the strength of wrought iron used in wire, rails, and bolts, in the new edition of his book on the strength of materials, but not as beams. (A Treatise on the Strength of Timber, Cast Iron, and Malleable Iron, and Other Materials... (London: John Weale, 1845).)

¹²³ William Fairbairn, On the Application of Cast and Wrought Iron to Building Purposes (London: John Weale, 1854), p. 74.

rolled in Britain.¹²⁴ The wrought iron beams Fairbairn illustrated in his text are I shaped girders made by riveting together plates, channels, and angles. (Illustration 3-6.) At any rate, despite his recommendations, British mill designers continued to use cast iron beams throughout the nineteenth century. Even with the extra amount of material required for a beam made of cast iron compared with one of similar strength in wrought iron, cast iron was cheaper.

Illustration 3-6. Wrought iron girder made of plates and angles.

WROUGHT-IRON PLATE GIRDER—EXAMPLE OF COST.



Americans did not begin rolling rails for railroads until the mid-1840s. While the production of rails increased over the decade -- about fifteen mills were making rails at the end of the decade -- technique developed slowly, and the quality of American-made rails was considered inferior to British rails. The great bulk of rails used in the U.S. continued to be imported from Britain. British rail dumping in the early 1850s put further pressure on American iron manufacturers and induced some to consider branching into product lines, such

¹²⁴ Lawrance Hurst, "The Age of Fireproof Flooring," p. 35. James Barrett, a builder, joined with Henry Hawes Fox, who installed the prototype of the floor in a private asylum in 1833, in 1848. Barrett changed the materials of the floor, replacing cast iron joists with rolled iron ones; the joists carried strips of wood, which served as permanent centering, and was filled with concrete. It began to be used in non-industrial buildings, including residences, to a great extent after 1850.

as beams for building construction, where competition would be less intense.¹²⁵ To make beams such as those Fairbairn illustrated in his book meant punching holes in rolled iron shapes and bolting the pieces together.¹²⁶ A mill had to be able to roll the shapes, but did not have to have the capability of making heavy, deep sections, such as would be required for solid beams. Because solid beams were superior to the made beams, at least two mill tried to make such beams beginning in the early 1850s. They did not succeed in rolling them until a few years later.

One of the first buildings in the U.S. in which rolled iron beams were used was Treasury's Assay Office in New York City, Bowman's first project as Engineer-in-Charge. The government purchased the property next door to its custom house on Wall Street, occupied by the former branch of the Bank of the United States (built 1822-23), for the purpose of establishing the Assay Office. It renovated the bank building for offices and built an addition behind the bank, for refining and storing bullion, between the fall of 1853 and fall of 1854.¹²⁷ Since operations of the foundry were hazardous, and the material refined and stored very valuable, much consideration was given to fire protection.

Bowman had planned a fireproof building with iron exterior walls, cast iron beams, and brick arch floors, but because the bids he received for the walls were so high, he decided to use brick instead. Price may also have been the reason he substituted wrought iron for cast iron beams. The original beams were to be cast iron arches with a wrought iron tie rod, 35 feet long and 27 3/4 inches deep, to be made from patterns of the architectural iron firms Bogardus & Hoppin and George R. Jackson & Co. But then he learned of wrought iron

¹²⁵ Esmond Shaw makes this suggestion in his pamphlet, Peter Cooper and the Wrought Iron Beam (New York: Cooper Union, School of Art and Architecture, 1960).

¹²⁶ No "made" beam from this period has ever been uncovered, and as far as I can tell, pieces were attached by bolting -- using screws and nuts -- rather than by rivetting, in which an iron plug more effectively welds the parts together.

¹²⁷ The only plans I have located of the elusive addition are 1873 drawings made to show how the floors of the building would be reinforced. (National Archives, Record Group 121, entry 26, New York Assay Office, box 286.) Thanks to Joseph T. Avery, Superintendent, Manhattan Sites, National Park Service, for information on the old bank. The Assay Office was demolished in 1915.

beams,

I have found some rolled wrought Iron beams, which are abundantly strong for our purposes, for less than half the price of the proposed "made beams," their cost about \$1000 less per floor than the lowest offer received. I have had a beam of this kind, fifteen feet between the supporters tested by 9000#s suspended from its middle point without permanent deflection.¹²⁸

These beams were double channels bolted together in the middle¹²⁹ and were manufactured by the Trenton Iron Company, also known as Cooper Hewitt and Company after the principals in the firm, Edward Cooper and Abram Hewitt, who were son and son-in-law, respectively, of the inventor and philanthropist, and the company's largest stockholder, Peter Cooper.¹³⁰ Many other prominent New York iron designers and founders were involved in the project: James Bogardus (iron cornice, perhaps window sashes and frames), George R. Jackson & Company (iron stairs, shutters), S. B. Althause & Company (iron floor),¹³¹ and Marshall Lefferts and Brother (iron roof). Iron accounted for about half of the cost of construction, \$39,500 of \$87,800.¹³² Bowman superintended the construction initially but

¹²⁸ Bowman to Guthrie, Oct. 7, 1853, NA, RG 121, entry 26, New York Assay Office.

¹²⁹ The beams for the Assay Office are listed in Trenton Iron Company shipping record book, dated Sept. 9, 1852 - March 25, 1854, as being "iron bars." (Cooper and Hewitt papers, manuscript collection, Library of Congress.) A report on the floors, dated Oct. 17, 1873, when repairs to the building were being planned, describes them as follows: "The girders are constructed of 7" and 8" channel iron bolted together, and the 8" floor beams are butting against these girders and fastened thereto with angle irons and bolts." (National Archives, RG 121, entry 26, New York Assay Office, box 286.) This information, unfortunately, does not entirely settle the matter of how the building was built.

¹³⁰ Esmond Shaw, Peter Cooper and the Wrought Iron Beam.

¹³¹ The Althause firm was paid over \$15,000 for "iron work" at the Assay Office, making it one of the largest iron contractors on the building. Cooper & Hewitt was paid only \$2,000 for the "Iron girders &c 6th story." The sixth floor was added after the building was under construction and the contracts had been let. Probably the Trenton beams used in the first five floors were ordered by Althause, who was the original low bidder for the floor, and this firm set the beams, while the 6th floor beams were ordered directly from Trenton. (National Archives, RG 121, entry 26, New York Assay Office.)

¹³² National Archives, RG 121, entry 26, New York Assay Office, box 285, abstracts of expenses for erecting the Assay Office.

after he left to assume duties in Washington in early 1854, George Cullum -- better known as the biographer of Military Academy graduates -- took over the construction.¹³³

This building was a model for government fireproof buildings over the next 20 years. Bowman wrote that "wrought iron beams, with segmental brick arches, were used for all the floors. The shutters, doors, sash and stairs are iron so that the building is perfectly fireproof."¹³⁴ Because it was practically hidden behind the old bank building on Wall Street, and inaccessible for security reasons, it was probably unknown to contemporaries. Nevertheless, what Bowman learned from building this structure he applied to subsequent buildings. These later Treasury Department buildings, unlike the Assay Office, were highly visible in their communities and consequently influential. Moreover, the materials manufacturers and builders involved with the project gained valuable experience with this system of construction from the Assay Office project. And the same firms that worked on government buildings built and supplied material for private fireproof buildings.

While the Assay Office was under construction, Cooper and Hewitt announced the availability of solid rolled beams. Trenton had been trying to roll these beams for fireproof floors for a few years, but did not succeed in making any by the time the floor beams were required for the Assay Office. In early 1854, Trenton was finally rolling iron beams -- the first American mill to do so.¹³⁵ Treasury adopted these beams immediately in place of cast

¹³³ Capt. Cullum was sent to the Assay Office in November, 1853, and left in June to return to West Point. General Trotter to Secretary of Treasury Guthrie, Nov. 12, 1853, and George Cullum to Guthrie, May 26, 1854, NA, RG 121, entry 26, Assay Office, box 285.

¹³⁴ Letter November 11, 1854, National Archives, RG 121, entry 6.

¹³⁵ In his article on the early history of the rolled beam, Robert Jewett concludes that the first rolled beam was simply a new use for an old style of railroad rail. ("Solving the Puzzle of the First American Structural Rail-Beam.") The Trenton mill rolled rails, and certainly the beam was an application of rolling methods such as those used in making rails. But from every indication in the business records I read from the 1850s and 1860s, Cooper and Hewitt intended to make a beam for use in fireproof buildings. Perhaps the clearest indication that there was a distinction between a beam and a rail is in the description of items that went to Princeton University. From other sources, we learn that although Cooper and Hewitt urged the architect of the reconstruction of the building to use beams, but he decided to use less expensive rails. In the order books, Princeton was sent tons of angle bars, bar iron, T bars,

iron joists, both for buildings being planned and under construction. For example, the plans for the custom house in Charleston called for cast iron beams, but the building took so long to rise above the foundation level that by the time it was ready to receive the upper floors (1857), wrought iron beams were available and they were used instead of cast iron.¹³⁶

The beams were rolled from pieces of puddled iron welded together, similar to the way railroad rails were made. But since beams had to be deeper and sometimes longer, and therefore were heavier, than rails, the technique for making them took longer to perfect. The first solid beams rolled at Trenton in fact were shaped like railroad rails -- asymmetrical in section, with a round head on one end and flat flange on the other, and were 7 inches high. The flange carried the brick arches. By the end of 1856, the company succeeded in rolling beams in the stronger I-shaped section.¹³⁷ The I quickly replaced the rail shaped beam, although the latter continued to be rolled for use in constructing the decks of iron ships, in which the flange side was up. By December, 1856, Trenton was rolling nine inch deep beams for longer spans.¹³⁸

At about this time, solid beams soon became available from another domestic source as well: Phoenix Iron Works in Phoenixville, between Philadelphia and Reading, Pennsylvania. In July, 1857, this firm wrote to Bowman that it could supply seven and nine

railroad iron, and rails, but just a few "beams." Cooper and Hewitt succeeded in rolling an I shaped beam soon after they introduced their first "solid" rolled beams. However, the asymmetrical beam, with a round head on one side and flat flange on the other, called a "deck beam," continued to be rolled throughout the century. It would be nice to know what the first Phoenix Iron beams looked like, but I have not been able to find out.

¹³⁶ NA, RG 121, entry 6, Charleston Custom House, boxes 133 and 134. The building was not finished until about 1879.

¹³⁷ Young to Hayward & Bartlett, December 30, 1856, describing an I shaped beam to be used in the Georgetown Custom House. These beams weighed from 29-30 pounds per foot, which is the same weight as the rail-shaped beam. (National Archives, RG 121, entry 6.) I can not tell from this record group exactly when the I shape first became available, and quotations in articles about the development of the beam are ambiguous.

¹³⁸ 176 nine inch beams shipped to U.S. Fort Sumter, entry Dec. 12, 1856, Day Book "I," Dec. 12, 1856 - Oct. 29, 1859, Cooper & Hewitt collection, Library of Congress.

inch beams "for use in government buildings."¹³⁹ Phoenix Iron was one of the larger iron mills in this period, and had been rolling railroad rails for about ten years. Like Trenton, it began preparing a beam mill in the early 1850s and succeeded in rolling beams a little after Trenton, in 1855.¹⁴⁰ The beams it offered were heavier than the common Trenton beams. That these two firms were the sole domestic sources of beams at the time is indicated by the fact that Hewitt was soon contact with Phoenix Iron to make an "agreement" concerning beam prices since "The business is as yet too inconsiderable for active competition."¹⁴¹

Because they are the ancestor of structural shape that became a fixture in steel frame construction -- the I beam -- the first "solid" rolled beams have been the subject of several histories.¹⁴² This literature leaves the impression that as soon as wrought iron beams were introduced, cast iron and made beams were abandoned. But this was not the case. Badger illustrated cast iron joists in his 1865 catalogue and cast iron continued to be used for girders during the 1860s. Throughout the nineteenth century, cast iron was used for lintels (a horizontal member bridging an opening, which usually supports a wall above it). There were several reasons why cast iron continued to be used. First, the early solid rolled beams were

¹³⁹ Phoenix Works to Bowman, July 13, 1857 (NA, RG 121, entry 6).

¹⁴⁰ Christopher Baer, "Phoenix Steel Corporation, Company History," accompanying the Phoenix Steel Co. inventory at Hagley Museum and Library, p. 2. The source of the information that Phoenix began construction of a structural shape mill in 1851 and rolled beams in 1855 was probably an article "The Development of the Iron and Steel Industry in Phoenixville," written in 1910. (Letter from Mr. Baer, Jan. 18, 1995.) However, it is impossible to tell from the extant business records when Phoenix's beams were first rolled and where they went.

¹⁴¹ Cooper Hewitt & Co. to Samuel Reeves, Phoenix Iron Col, Feb. 16, 1857, Phoenix Steel Co. papers, Hagley Museum and Library.

¹⁴² Histories of the development of the beam are in Esmond Shaw, Peter Cooper and the Wrought Iron Beam; Robert Jewett, "Solving the Puzzle of the First American Rail-Beam;" and Charles Peterson, "Inventing the I Beam: Richard Turner, Cooper & Hewitt and Others," in H. Ward Jandl, The Technology of Historic American Buildings (Washington: Foundation for Preservation Technology, 1983).

small -- roughly seven or nine inches deep and at most 22 feet long¹⁴³. These were sometimes doubled to make girders -- an inelegant solution. Although cast iron girders were heavier than wrought iron, they were not any less functional. When girders of greater dimensions were required, they were built up from pieces of cast iron, either alone or combined with wrought iron, or from plates, channels, and angles of rolled iron, bolted or riveted together. A model for a hollow girder was the "tubular" girders devised by Fairbairn for the Menai Straits bridge of the 1840s.¹⁴⁴ A second reason was high price and limited availability of solid iron beams suitable for girders. In the 1860s, rolled beams of greater depth became available but mills were reluctant to put up rollers for deep beams except for large orders.¹⁴⁵ The girders made of metal shapes could be fabricated by architectural iron works, which made their own castings and used rolled pieces obtained from rolling mills, whereas rolled beams were only available from a limited number of mills.

As a large and steady client of manufacturers of building iron, the Treasury encouraged the development of this branch of the industry. The government was obliged to buy American, a requirement Bowman supported, and Congress requested reports on its iron consumption. Iron masters comprised one of the most vocal interest groups and were forever pressing Congress to pass tariff legislation to provide what they considered adequate protection from imports. Bowman assured the founder, Marshall Lefferts, that the Secretary of the Treasury "is aiming by all legitimate means in his power to favor this very important branch of American Industry."¹⁴⁶ The Department placed large orders of beams with Trenton Iron, which apparently was the only domestic source for solid rolled iron beams

¹⁴³ On length, Robert Jewett, "Solving the Puzzle of the First American Structural Rail-Beam," quoting a letter from Cooper and Hewitt of August 12, 1854, p. 389.

¹⁴⁴ Illustrations of these tubular girders and a discussion of tests was published in JFI vol. 12 3rd series (1846), pp. 24-28 and pp. 85-89.

¹⁴⁵ Architectural Review and American Builders' Journal vol. 1 (1869), p. 104.

¹⁴⁶ Bowman to Marshall Lefferts & Bro., New York, Aug. 3, 1855, NA, RG 121, entry 6.

when the bulk of its new buildings got underway.¹⁴⁷ The Department supplied beams to the job sites. Trenton beams also were used in the U.S. Capitol, which was undergoing renovation in this decade, and an extension to the post office in Washington -- neither of which were under the Treasury Department. New, private construction fell off with the Panic of 1857¹⁴⁸ and only picked up again following the Civil War, but a backlog of orders for structural iron placed before the Panic kept Trenton operating through the economic downturn.¹⁴⁹ Cooper and Hewitt were staunch Democrats, the party then in power in Washington, which probably helped Trenton Iron Company keep government business.¹⁵⁰

Another way in which the government promoted this new style of construction was by conducting tests of iron and publishing the results. A representative of the Department was stationed at the Trenton mill to weigh and check the material made for the government buildings. The practice of having an agent of the government inspect materials was an old one: agents were commonly appointed to certify that stone shipped from quarries met contract specifications and to weigh iron to be paid for by the pound before it left the foundry.¹⁵¹ What was unique about the situation at Trenton is that the government also ordered experiments to discover the load carrying capacity and best shapes for beams: thus, testing equipment was used not only to prove beams, but to learn about the performance of materials with which Americans had had little actual experience.

¹⁴⁷ Bowman, in a letter to Cooper & Hewitt, June 6, 1857, asked if beams offered by Hittinger and Cook, of Boston, for 3/4 cents less per pound than the Trenton price, were of foreign make, because the government would not use foreign iron.

¹⁴⁸ Bowman letter June 17, 1958, stating no new work will commence "while the finances (of the government) remain embarrassed." (NA, RG 121, entry 6.)

¹⁴⁹ Alan Nevins, Abram Hewitt (New York: Harper & Brothers, 1935). Although the Trenton mill continued to make bars and rails for private customers, the rolling mill products probably went exclusively to the government during the recession.

¹⁵⁰ Alan Nevins, Abram Hewitt.

¹⁵¹ For example, G. J. F. Bryant and Young both had worked as stone inspectors in their careers. Henry Lawrence was appointed to weigh castings for the 1852 Library of Congress at Janes, Bebee & Co. in New York. (Certificate of Henry Lawrence, June 22, 1852, Philadelphia Athenaeum, T. U. W. collection, papers, box 13, Congressional Library.)

Between 1855 and 1859, the government inspector was Robert Anderson.¹⁵² He was aided for a period at the mill by another military trained engineer, Gustavus Smith. Smith had resigned his commission in 1854 and became superintendent of the construction of the south wing of the Treasury Department¹⁵³ and then the marine hospital in New Orleans, projects directed by Treasury's Office of Construction. From 1856-57, a period when Trenton had huge orders for structural iron, Smith was chief engineer for the mill.

Bowman considered his first essay in iron and brick fireproof construction, the Assay Office, imperfect because he had used too many beams, thereby unnecessarily increasing the cost. With so many fireproof Treasury Department buildings in the planning stages, and "in view of the probable adoption of rolled beams and galvanized iron in many of the public buildings being erected," he requested government funds to conduct tests of the strength and durability of the beams, noting "As a matter of general interest to builders, [these tests] could not fail to be a popular measure."¹⁵⁴ Whether Congress provided the \$3,500 that was eventually requested for this purpose, I have not discovered, but tests nevertheless were made.¹⁵⁵ Perhaps the first tests of wrought iron beams, made a year before the request for additional funds, were reported to the government in April, 1854. Both riveted and solid

¹⁵² Letters in NA, RG 121, entry 6, dated Nov. 7, 1855, Sept. 20, 1856, and May 18, 1858, are addressed to Robert Anderson, U.S. inspecting agent, at Trenton. Anderson's specialty was artillery. Anderson's dates of service as iron work inspector, according to George Cullum, were July 20, 1855 to Nov. 15, 1859 (G. Cullum, Biographical Register of the Officers vol. 1 (1891).) I have not been able to find out whether Anderson was full-time at Trenton during these four years or exactly what he was doing during this period.

¹⁵³ Letter dated July 11, 1855: G. W. Smith accepts appointment at Superintendent of Work, NA, RG 121, entry 26, Treasury Extension, box 1422.

¹⁵⁴ Bowman to James Guthrie, March 18, 1854, NA, RG 121, entry 6.

¹⁵⁵ "Letter of the Secretary of the Treasury to Hon. Mr. Hunter, Chairman, Committee on Finance," Senate Executive Document No. 54, 33rd Congress 2nd session, 1854-55, serial set no. 752. The letter requested \$3,500 for a "complete series of tests" of iron beams.

rolled beams were tested.¹⁵⁶ Another set of tests, witnessed by Barton S. Alexander, the Corps of Engineers officer who was then completing the original Smithsonian Institution building in Washington, were made at Trenton in between October and the end of December, 1854.¹⁵⁷ Solid rolled beams were tested at this time, as well as the type of girder that was most commonly used in the federal buildings in the 1850s -- a box girder. The government tested beams rolled by other manufacturers when they became available. For example, Phoenix Iron beams were tested at Trenton by Major Anderson in 1857; Morris Jones & Co. was invited to send its girders to Trenton for testing.¹⁵⁸ (It was usual for the beams and girders tested to be supplied by the manufacturers at no cost to the government.) Tests of the elasticity of rolled iron beams were made in 1859 by Anderson for Trenton.¹⁵⁹

Besides the interior structural iron, another novel feature of the Treasury Department buildings was the use of iron roofs. Whether the American iron roof was inspired by British or French models, I can not say. No comprehensive study of iron roofs on fireproof mills in Britain has been undertaken; such information as has been compiled through industrial building surveys shows that iron roofs were not uncommon, and some were triangulated frames, such as were used in the American buildings.¹⁶⁰ These roofs also used a combination of wrought and cast iron parts, as did some of the American roofs. French roofs, such as were illustrated in Eck's 1836 treatise on wrought iron and pottery buildings, also

¹⁵⁶ Robert Jewett, "Solving the Puzzle of the First American Rail-Beam," p. 389. Jewett implies that the tests were conducted at Trenton Iron Works. But at about this time, tests were made of beams and arches at Marshall Lefferts and Brother, New York iron dealers. (Bowman to Marshall Lefferts & Brother, New York, May 9, 1854, NA, RG 121, entry 6.) I have not been able to see the source Jewett cites.

¹⁵⁷ Some of test results were attached to the 1855 letter, "Letter of the Secretary of the Treasury to Hon. Mr. Hunter," Senate Exec. Doc. No. 54, 33rd Congress 2nd session, 1854-55, serial set. no. 752. Cited in Charles Peterson, "Inventing the I-beam," p. 83.

¹⁵⁸ Letters dated July 13, 1857 and December 15, 1857, relative to Phoenix tests, and April 5, 1857, letter from Bowman to Morris Jones & Co., NA, RG 121, entry 6.

¹⁵⁹ R. G. Hatfield, "Fireproof Floors for Banks, Insurance Companies, Office Buildings and Dwellings," A.I.A., Proceedings of the Second Annual Convention, 1868, p. 34.

¹⁶⁰ Keith Falconer, "Fireproof Mills," pp. 16-19.

were triangulated, although probably the material of the members was entirely wrought iron.

The American roofs were covered with sheets of corrugated, galvanized, rolled iron. These large sheets, rolled for boiler plate, were a practical alternative to small pieces -- the tinned, lead, and other metal pieces that had been used as an alternative to slate for a fireproof roof since the turn of the nineteenth century. An improvement in the sheets was to roll in ridges, called corrugations. The corrugations made it possible for a roof of the plates without rafters; the sheets were laid on the iron roof trusses, overlapped and riveted at the junctures. These sheets were "invented" in about 1830 by a Mr. Walker in England, and reportedly were used on London dock buildings, in the form of a self-supporting arch.¹⁶¹ News of this material was carried in the Journal of the Franklin Institute.

Both Parris and Notman recommended iron roofs covered with slate or copper for fireproof buildings, such as were being put on public buildings in England according to Parris, but such roofs too were quite rare at this time.¹⁶² The only example is the well-known roof of the gas works in Philadelphia, built under the superintendence of Samuel V. Merrick (1801-1870) in the mid-1830s.¹⁶³ Iron roofs were being built on fireproof mills in England since the first decade of the nineteenth century, and from an earlier date, over government buildings in France.¹⁶⁴ By the 1820s and 1830s, iron roofs were put on

¹⁶¹ "Walker's Corrugated Iron Roofs and Gates," JFI vol. 12 ns (1833), pp. 43-45, reprint from Mechanics Magazine; corrugated iron also discussed in Diana Waite, editor, Architectural Elements, The Technological Revolution, American Historical Catalog Collection (Princeton: The Pyne Press, no date).

¹⁶² In 1846, John Notman proposed an ornate iron roof frame for the reconstruction of the fire damaged Pennsylvania Academy of Fine Arts. (Constance Greiff, John Notman, p. 111.)

¹⁶³ Illustrated in William Strickland, et al., Public Works of the United States of America, in two parts (London: John Weale, Architectural Library, 1841). Merrick established the Southwark iron foundry in Philadelphia at about this time, which specialized in making castings for machinery and did not, so far as I can tell, go in to the architectural iron line of work.

¹⁶⁴ Keith Falconer, "Fireproof Mills," pp. 16-19; Charles Eck, Traite de Construction en Poteries et Fer (Paris: J. C. Blosse, 1836), for illustrations of iron roofs over fireproof buildings in France.

military and gas manufacturing buildings in Britain.¹⁶⁵ The contracts for the roofs of the federal buildings at this time were separate from the iron work contracts, although the firms that bid on them also bid on the iron work. Bidders for the iron roof for the New York Assay office were: Bogardus and Hoppin, G. R. Jackson and Co., Marshall Lefferts, and Janes and Beebe.

In Bowman's view, the government was working out many of the kinks in the new system of construction for the benefit of the building industry of the nation. He used the prominence of his office to spread information about the new methods and materials of construction. The Department made plans of its fireproof buildings widely available. It advertised widely for bids, often in a great number of newspapers in each city, and sent bid packages, containing fine lithographs of the plans and details of the buildings, to applicants, apparently at no charge. Builders receiving the bid documents could see details for the construction of the buildings and read the specifications. A more direct attempt to spread knowledge was through the wide distribution of the building designs. Bowman had the lithographs of plans and construction details prepared for the bid documents collected in volumes and sent to "principal colleges in each state," as well as public libraries around the U.S., and to representatives of foreign countries as well, to show American progress in the building arts. A letter accompanying the volumes explained, "The introduction of wrought iron beams and girders it is believed is new, and so far has been entirely successful."¹⁶⁶

Another way the Department spread information about new construction methods was by serving as a reference bureau for inquiries about building materials -- directing writers to sources of supply -- and by maintaining a sample room at its headquarters, where they could be examined by the public. For example, in encouraging S. I. Ravenel of Charleston to donate a sample of his invention, a substitute for brick, to the government, Bowman described the sample room as a place "where we have building materials from all parts of the United

¹⁶⁵ Keith Falconer, "Fireproof Mills," p. 17.

¹⁶⁶ Bowman, October 8, 1856, National Archives, Record Group 121, entry 6. These volumes are titled, "Plans of Public Buildings in the Course of Construction under Direction of the Secretary of the Treasury, Including Specifications Thereof." I have used copies at the Boston Public Library, Harvard University, Library of Congress, and National Archives.

States, and where (his invention) will be more readily made known than in almost any other way you could adopt."¹⁶⁷

But the most important means of diffusion was the demonstration effect. Iron and brick fireproof Treasury buildings were built in cities all over the country; approximately 57 were built between 1855 and 1860.¹⁶⁸ No alert builder could have missed the arrival of a new federal building. In many cases, local builders won the construction contracts and so gained experience with this form of construction.

Bowman and other West Point graduates in the Engineers Corps -- Alexander, Anderson, Beauregard, and Franklin, for example -- not only helped establish the iron and brick system in this pioneering phase, in the mid-1850s, but helped spread it to private industry. Franklin worked as a consulting engineer on a new, fireproof capitol building for the State of Connecticut in the 1870s.¹⁶⁹ Bowman, in a letter to Col. Sylvanus Thayer of the Corps of Engineers in 1856, acknowledged the importance of his training in preparing him for the challenges of working with new construction materials, writing that he had been laboring

for the past few years ... to improve our Public Buildings by rendering them strictly fireproof. The introduction of Wrought Iron Beams of the kinds used in the structures, I believe is new,-- ... a novel feature of so much importance, you are aware, would encounter many difficulties. That I have succeeded in overcoming them, as well as many other met on these works, I owe entirely to the training I received at the

¹⁶⁷ Letter dated October 18, 1956, National Archives, RG 121, entry 6.

¹⁶⁸ I count 42 office buildings (custom house-post office-court house buildings); 9 marine hospitals; and 6 other kinds of buildings, authorized in records of the Treasury. I am not sure that every one of these buildings was actually constructed in this period. (NA, RG 121.)

¹⁶⁹ G. Cullum, Biographical Register, mentions Franklin's civilian career after he resigned from the military and moved to Hartford in November, 1865, to work for the Colt Fire-Arms Manufacturing Co. He undoubtedly was involved with the reconstruction of Colt's East Armory building, on which work began in 1866. This building is one of the few iron and brick factory buildings in the U.S. and it may be so because of Franklin's presence. Franklin was acquainted with the fireproof construction methods used by the Office of Construction of the Treasury Department, as he had served briefly in the position Engineer-in-Charge, in 1861, until the start of the Civil War. (Information on Colt Armory from William Hosley, Wadsworth Atheneum.)

Institution (West Point)...¹⁷⁰

It should be noted that he is undoubtedly referring to his general engineering training, not to any specific instruction in the use of iron structurally. As he suggests, the Treasury buildings were among the first in the U.S. in which iron beams were used. Nor was iron used in bridge construction in the U.S. before the 1850s, save for a few rare examples. Iron in buildings was not, therefore, a matter of transferring bridge engineering knowledge to buildings; bridge manufacturers did not begin to work on buildings until later. The combination truss-suspension bridges had no applicability to building construction and even the beam-type trusses were designed for conditions -- spans and loads -- that were not present in most buildings. Iron building frames were made of posts and girders, with iron essentially substituting for wood -- "iron joinery," as one contemporary called the system. The only commonality between truss bridges and buildings was in the roofs. Here to, though, iron truss framing in roofs resembled triangulated wood truss framing. Bridge builders entered the building market about 1870, and then through roof construction contracts.

Increase in Fireproof Construction

With the introduction of the iron and brick system, private owners began to build fireproof buildings to a much greater extent. Since private owners had little experience fireproof systems, how were they convinced to use the new system? This question is important because it helps explain when rolling mills entered the beam market. Beams had the advantage of being a niche product, insulated from the competitive pressures rails faced, but still demand for the product had to be built. The applications for iron beams was fairly confined to buildings; there was no great demand for structural iron from engineering works. Unlike in England, iron bridge construction was in its infancy in the U.S. in the 1850s. Thus, for the beams to sell, building owners had to want to build fireproof buildings.

Fairbairn's book -- scientific, authoritative, yet accessible -- appearing as it did, just when solid rolled beams became available, must have been a great help in this regard. Although it presented no new information, it was the first book that discussed iron specifically in connection with fireproof building construction -- with illustrations and

¹⁷⁰ Letter dated December 11, 1856, NA, RG 121, entry 6.

examples of extant buildings -- and therefore was more of a construction handbook than, for example, Hodgkinson's edition of Tredgold's Essay. French language books showing wrought iron construction were available, for example Charles Eck's Traite de Construction en Poteries et Fer, but French methods of fireproof construction, involving truss beams made of wrought iron and floors of hollow pots or concrete, did not catch on.¹⁷¹ Cooper & Hewitt specifically mentioned the work of the English engineers in the marketing literature for their beams.¹⁷²

The way to greater use was led by the manufacturers and the technically oriented architects who had read about, or had experience with, the cast iron beam and brick system. What was different in this period was that new kinds of buildings began to be built with iron and brick, beyond the traditional pool of government, institutions, and banks. Wrought iron was quickly adopted in the traditional type of project, for example, the South Carolina State House, mentioned above, was begun with cast iron beams and finished with wrought iron.¹⁷³ But cities were growing at a great pace in the 1850s and as a larger share of the construction went to fireproof buildings, the number of such buildings greatly increased.

While it is impossible to know exactly how many fireproof buildings were constructed in the 1850s, what is certain is that the iron and brick system was adopted quickly and the number of such buildings increased tremendously. In March, 1855, Cooper & Hewitt wrote to the President of Princeton College, who was about to repair a fire-damaged college building, "we have orders on hand for over fifty buildings, although we have been able to

¹⁷¹ The book was published in Paris in 1836. The copy I used was owned by the American engineer, Loammi Baldwin.

¹⁷² For example, as early as 1854, Cooper & Hewitt advertised their wrought iron girders as "constructed on the most approved philosophical principles developed in the thorough experiments of Messrs. Stephenson, Hodgkinson, and Fairbairn, made in reference to the construction of the Great Tubular Bridge over the Menai Straits." Quoted in Charles Peterson, "Inventing the I-Beam," p. 84.

¹⁷³ Orders for beams for this building were placed with Trenton Iron Works in 1858 and 1860 (Day Books, item 418 and item 395, Cooper Hewitt Collection, Library of Congress, Manuscript Division).

make beams only about 6 mos."¹⁷⁴ These included buildings for the traditional customers and for the new commercial/industrial owners.

Probably the first example of a commercial building in which the new beams were used was the offices and shops of the Harper and Brothers publishers in Franklin Square. This building (actually two connected buildings) has been discussed in connection with the history of the I beam, but not as an exemplar of fireproof construction. It was famous in its day as a model, fireproof building, described in 1869 as "one of the pioneer buildings of the new dispensation."¹⁷⁵ The building was constructed to replace one destroyed in a fire in December, 1853. Although Harper Brothers' loss was large and the company was not fully insured -- reportedly because of the high cost of fire insurance -- nevertheless, their printing plates survived in "fire-proof, subterranean vaults" and the brothers decided to continue the business.¹⁷⁶ They contracted with John B. Corlies, an architect and builder, to build a fireproof building. Corlies might have used cast iron beams, but Abram Hewitt reportedly informed the owners of the availability of their new product, and the brothers opted to use it.

The way the building was constructed was described in great detail in a book about the Harper establishment that was published in 1855, the year the new building was completed. Probably the reason so much attention was devoted to the building, in a book about the doings of the publishing house, was to show that Harper was progressive and unsparing in pursuit of excellence. The chapter on "fire-proof floors," reportedly written by Hewitt, described the Harper floors as an improvement over the solid masonry type because they were thinner, with each section self-sustaining, and could be supported by thinner walls.

¹⁷⁴ Letter reproduced in Constance Greiff, John Notman, p. 204. The architect in charge of reconstructing this building, John Notman, ordered mainly ordinary rolled shapes rather than Trenton's deeper, and more costly, beams. A Cooper & Hewitt day book shows large orders of rails, angle bar, bar iron, T bars, and some beams for Princeton College in July and August, 1855. (Cooper Hewitt collection, Day Book, item 391, Library of Congress, Manuscript Division.)

¹⁷⁵ Peter Wight, "Remarks on Fire-Proof Construction," ARABJ vol. 2 (August, 1869), p. 102.

¹⁷⁶ Eugene Exman, The Brothers Harper (New York: Harper & Row, 1965). This book also is the source of information about Harper's fire insurance coverage.

The floor was a combination of cast iron girders and wrought iron beams. The cast iron girders were shaped in an arch and tied with a wrought iron rod, and were more or less elaborately ornamented, according to whether they were in public rooms or work rooms. Cast into the top edge of the girder were brackets for holding solid rolled beams. The beams were spaced four feet apart, and between them were brick arches, filled and leveled up with concrete.¹⁷⁷ (Illustration 3-7.)

The floors were not the only fire protection measure taken in this building. It was divided into two sections, separated by a courtyard, so that a fire in one part would not involve the entire building immediately. To reduce openings in the floors -- through which rising flames and smoke could spread to upper floors -- a staircase was built between the two buildings in its own tower and was connected to the buildings by iron bridges. While by modern standards, the egress provisions were inadequate, the attention to given isolating space and protecting the stairs is remarkable. This book not only was good publicity for the publisher, but also for Trenton and its beams. Readers were invited to Trenton Iron Works for a tour.

Moreover, the manufacturers and builders who worked on the Harper building and the government buildings went on to spread the use of the system. The girders in the Harper building were designed and manufactured by James L. Jackson of Jackson Architectural Iron Works (apparently no relation to George R. Jackson, who also operated a foundry in New York in the 1850s).¹⁷⁸ James Bogardus was the contractor for the iron facade on the Franklin Square side of the building. Bogardus did not have to produce new patterns for this project; he already had an appropriate front for a printing establishment, complete with a bust

¹⁷⁷ Jacob Abbott, The Harper Establishment; or, How the Story Books Are Made (Hamden, Conn.: The Shoestring Press, 1956) reprint of 1855 original.

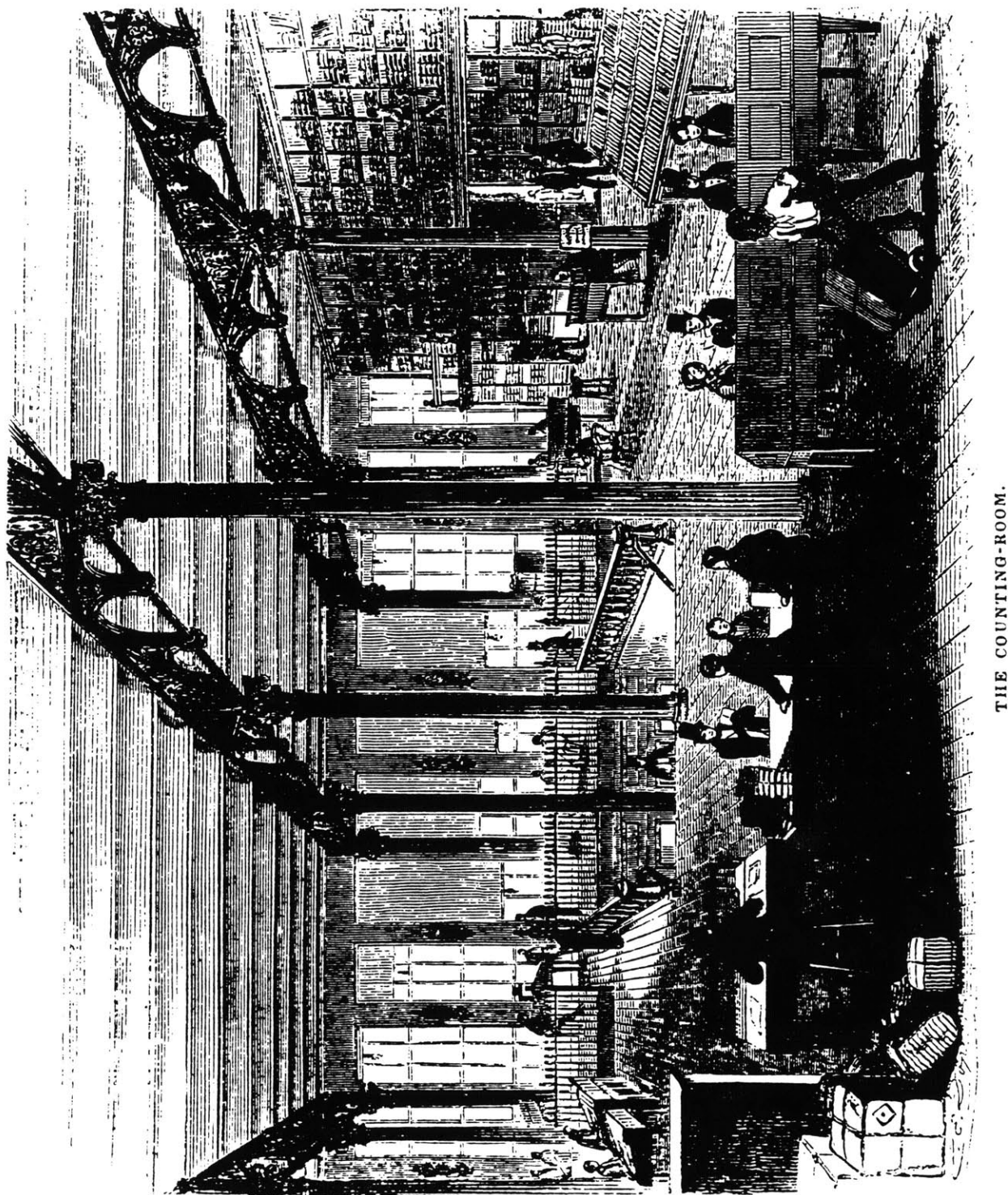
¹⁷⁸ James L. Jackson's foundry began in 1840 as a manufacturer of grates and fenders and in 1857 established a new plant at 315 East 28th Street. It was one of the half dozen foundries still in business in New York at the end of the century. (A History of Real Estate... in New York (New York: Arno Press, 1967) reprint of 1898, pp. 485-487.) George R. Jackson & Co., also called Excelsior Iron Works in 1854, was located at 201 Center Street, New York. (Records of the Public Building Service, NA, RG 121, entry 26, box 80 -- Belfast, Maine Custom House, letter dated July 4, 1855).

Illustration 3-7. Harper Bros. building, showing the arched, fireproof floor.

16

GENERAL STRUCTURE OF THE EDIFICE.

View of the interior of the counting-room.



of Benjamin Franklin -- that of his Sun Building in Baltimore. He ordered the Sun facade duplicated at the Baltimore foundry of Hayward, Bartlett & Company and shipped to New York.¹⁷⁹

Because they were the main (and briefly the only) domestic source of solid beams, the business records of Trenton Iron Works are an excellent source for learning where and what kind of buildings were constructed fireproof.¹⁸⁰ Beams, both wrought iron and probably cast iron too, also were imported, but unfortunately it is impossible to trace where these beams were used. Of the buildings that are listed in the Trenton business records, many can be positively identified as fireproof buildings.¹⁸¹ Rarely were beams used in interior framing of buildings except as part of fireproof construction, for the sake of incombustibility. Of course, structural iron was used in other applications too, for examples for lintels over doors and windows. But when a large number of beams were used in a building, the structure was to some extent fireproof. Thus, architects and builders gained experience using iron structurally almost entirely in connection with constructing fireproof buildings.

Most of Trenton's beams in the 1850s went to government buildings, but of the private customers, most were in New York City. A virtuous cycle began, with materials manufacturers, designers, and tradesmen spreading information, encouraging demand, and gaining experience. New York's proximity to Trenton was also a factor, although Philadelphia, another large and growing city near both the Trenton Iron and Phoenix Iron

¹⁷⁹ David Wright, "The Sun Iron Building," pp. 29-30; Ferdinand Latrobe, Iron Men, p. 22.

¹⁸⁰ Cooper Hewitt Collection, Manuscript Division, Library of Congress. The collection contains business records of Trenton Iron Works, including books that list customers and the products they ordered, usually with the weight and price. I studied records from the period 1852 to 1873. Day books and order books cover this period with only a few gaps; the period 1852-1854 is covered by an Iron Business Shipping Record book.

¹⁸¹ The Trenton records list the customer and the products being sent. Sometimes only the name of the customer is given and not the building for which the products were destined, in which case it is impossible to know how they were used. But often a building is listed, and I have tracked down a great many of these buildings. In the great majority of cases, I have found that the building in which beams were used were entirely or partially fireproof.

mills, does not seem to have experienced a similar boom in iron and brick fireproof building construction. New York City became the center of fireproof construction in the 1850s and 1860s, and probably had the greatest number of fireproof buildings of any U.S. city.

Examples of Trenton Iron Work's early customers in New York City were the Continental Bank building on Nassau Street and the American Exchange Bank Building on Broadway, designed by Leopold Eidlitz. Iron beams, angle iron, pillars, and columns were shipped for the former building from Trenton in 1856 and 1857, and beams and box girders were shipped for the latter in 1857. When Montgomery Schuyler called the American Exchange Bank the "first fireproof building erected for commercial purposes in New York,"¹⁸² he must have meant the first fireproof building in New York built for rent, since the Harper Brothers building predates it by a year. The Harper building was completely occupied by the publisher, whereas rooms in the fireproof office buildings were available for tenants seeking secure quarters. The American Institute of Architects rented offices in the American Exchange Bank, in order to have a safe location for their library.

Another office building from this period was the "partially fire-proof"¹⁸³ New York Times Building at Park Row and Nassau Street (Thomas R. Jackson, architect, and Stone and Witt, contractors), to which 28 nine inch beams, plus 10 more beams of unknown size, were shipped from Trenton in 1857. Since this is a small number of beams, probably the building had a fireproof floor only over or under the presses, so while the tenants' offices were combustible, at least they were somewhat protected from a fire in the press rooms. A large beam order -- 148 nine inch beams -- was shipped in 1857 for Tompkins Market/Armory (1857-60) at Third Avenue and Sixth Street; however, this building had four cast iron facades and therefore could not easily have taken the weight of two floors of iron and brick arches. Considering the building was designed by Marshall Lefferts, an important manufacturer

¹⁸² Montgomery Schuyler, "A Great American Architect: Leopold Eidlitz," The Architectural Record vol. 24 (July-December, 1908), p. 280.

¹⁸³ Peter Wight, "Remarks on Fire-Proof Construction," p. 102.

corrugated iron and iron roofs, it is likely that the beams were used to construct the roof.¹⁸⁴ The Mechanics Bank on Wall Street was sent 72 iron beams in 1855.

The cost of iron and brick buildings was still considerably higher than ordinary construction, and one way to help pay for such a building was to build extra space for rent. Owners who wished to build fireproof buildings -- like the New York Times company -- were encouraged to build them larger and larger and pay for them with the rents earned on extra space. This phenomenon will be discussed further in Chapter 6.

Trenton beams were used in buildings in New York whose owners were the traditional clients for fireproof construction -- institutions -- and also a new type, buildings owned by insurance companies. A famous example of the former type from this period is the Cooper Institute building. In 1855, huge quantities of rolled beams were being sent to Peter Cooper for his Institute Building (completed in 1858).¹⁸⁵ The extension of the Astor Library at 425 Lafayette Street, for which the builder, S. B. Althause, was shipped 90 nine inch beams in 1857, is another example.¹⁸⁶ This building was designed by Griffith Thomas (1820-1879)

¹⁸⁴ In reporting on the burning of the roof of the building in 1874, the New York Times mentioned that Lefferts, a colonel in the Seventh Regiment of New York, was the designer. (July 26, 1874, p. 8.) The Regiment occupied the second and third floor of this building. I. N. P. Stokes, Iconography of Manhattan Island, cited by T. Bannister, "Bogardus Revisited; Part I," footnote 51, says the building was constructed from plans by "Bogardus and Lafferty." However, Bogardus did not include this building among his projects. And the roof, which leaked, certainly behaved like the other iron roofs of the period. The fire apparently was started by workmen who were repairing the roof. It was replaced a third time with a wooden roof designed by Leopold Eidlitz. (M. Schuyler, Architectural Record vol. 24 (July-Dec., 1908), p. 170.)

¹⁸⁵ Iron Business Shipping Record, Sept. 9, 1852 - March 25, 1854, Cooper & Hewitt collection, Library of Congress, Manuscript Division. In October and November, 1853, 96 "iron beams" were sent to Peter Cooper in seven shipments. This predates the availability of solid rolled beams; what these were and how they were used is still a mystery.

¹⁸⁶ Library of Congress, C & H collection, Cooper Hewitt daybook, shipment April 14, 1857. The first part of the building opened in 1854 and the extension opened in 1859. Robert Jewett lists the Astor Library as a possible contender for having used rolled beams in advance of the Cooper Union, but was uncertain. ("Solving the Puzzle of the First American Structural Rail-Beam," p. 386.) To clear up the matter, from the shipment dates, that the beams for the Astor Library were much later than the beams for the Cooper Institute.

who, in collaboration with his father and on his own, designed many cast iron front buildings, and also several fireproof buildings. Thomas also designed a building for an insurance company. In December 1861, he completed a new building for Continental Insurance Company at 102 Broadway. Two cast iron fronts were made for this building by Architectural Iron Works. An insurance journalist wrote of this building, "When the other buildings of our great city become as safe from risk of fire as the new Continental building, there will be little need for fire insurance companies" -- not an eventually Continental could hope for.¹⁸⁷

Iron and brick fireproof construction began to appear outside of New York as well, in the work of architects who had experience designing fireproof buildings and architectural iron works, like Daniel Badger's company, which served a national market. Trenton beams were shipped for a number of projects in the mid-Atlantic region in the 1850s. One example was the Bank of Pennsylvania at 421 Chestnut Street, for which 182 nine inch beams were shipped from Trenton in 1857.¹⁸⁸ The bank failed in the 1857 panic, while still under construction, and was finished by the Philadelphia Bank. This bank, and its next door neighbor, were designed by John M. Gries and contained a great amount of cast iron, supplied by the foundry of H. C. Oram & Co., which is noted on a plaque on the front of the building.

Phoenix Iron Co. competed with Trenton for Philadelphia contracts, but the surviving business records from this company do not reveal where its beams were sent. The record of fireproof construction in Philadelphia is hard to reconstruct. Given the city's long-standing interest in fireproof construction and busy foundry business, we would expect to see more of the iron and brick fireproof buildings than I have been able to document.

Seventeen "trough bars" were sent to the Library in 1855; this was the earliest shipment.

¹⁸⁷ Ann Kelchburg with Ronald Mullins, A History of the Continental Insurance Company (New York: The Continental Corporation, 1979), p. 14.

¹⁸⁸ Copper Hewitt daybook, March 25, 1857 and April 29, 1857. A drawing of this building -- a section of the front banking room -- shows the arches in the banking room (collection of the Philadelphia Athenaeum). Trenton competed with Phoenix Iron to supply beams for this building. (Letter from Cooper Hewitt & Co. to Samuel Reeves, Feb. 16, 1857, Phoenix Steel Co. papers, Hagley Museum and Library.)

New Englanders seem to have been less enthusiastic about fireproof construction than the people of the mid-Atlantic and more inclined to build fireproof rooms than thoroughly fireproof buildings. Boston did not have an architectural iron industry on the scale of New York's at this time, rather iron building work was done by non-specialist foundries and machine makers.¹⁸⁹ Smith, Felton & Co., makers of bank vaults and safes, were among Trenton's few New England customers. One of its projects was the fireproof vault in the old Suffolk Bank by Isaiah Rogers at 60 State Street: 143 nine inch beams, 25 trough bars, 10 seven inch beams, and 4 girders shipped from Trenton to this project in 1856 and 1857. Another was the Traders Bank Building by Nathaniel Bradlee (1829-1888) at 91 State Street, which was designed to be fireproof throughout.¹⁹⁰ The third was the third floor of an unnamed building at State and Congress Streets, possibly Merchants' National Bank, which added a third floor at this time.¹⁹¹ The other fireproof buildings and strong rooms in Boston were for government clients. In 1859, Smith, Felton & Co. used Trenton material to build a fireproof room inside the old building at 30 Tremont Street for Boston's Registry of Deeds.¹⁹² Another Boston firm that used Trenton's rolled iron in fireproof building projects was Denio & Roberts, blacksmiths and machinists.

In the West, some private buildings in Chicago reportedly were built fireproof, as well as important public projects. Henry Ericsson, a Chicago builder, building official, and student of building history in the city, wrote that some of the iron-front stores that were built in

¹⁸⁹ Boston Directory (Boston: George Adams and Adams, Sampson & Co.), for the years 1857-1860.

¹⁹⁰ The design for this building called for three floors of iron beams and brick arches, so presumably the 26 9 inch beams shipped in 1858 were only an installment. A drawing of a section of the building is in James O'Gorman, On the Boards (Philadelphia: U. of Pennsylvania Press, 1989), p. 51. The building was demolished in the nineteenth century.

¹⁹¹ This building was on State Street, opposite Congress Street. Gridley J. G. Bryant was the architect of the interior, and he had recently been designing fireproof buildings. (AABN vol. 7 (Feb. 14, 1880), p. 58.) Forty-six 9 inch beams were shipped for the State and Congress Streets project in 1857.

¹⁹² The City Hall, Boston (Boston: by the City Council, 1866), p. 50.

Chicago in the 1850s and early 1860s were fireproof, specifically the Thomas Church building. Ericsson specifically notes that all of the iron-front stores on Lake Street, of which Church's building was one, were constructed for rent, not for the use of the owner.¹⁹³ This is surprising, since it is hard to think what sort of merchant would pay the presumably higher rent in such a building. Government, of course, built for its own use and so could justify the higher cost of materials for the sake of permanence and security. In 1857, 82 nine inch beams were shipped to the Detroit Water Works, and the next year, 92 nine inch beams were shipped to Chicago for its Water Works. The water works system in Chicago was a great technological achievement, consisting of a pumping engine that drew water from Lake Michigan via a long tunnel and raised it into a tower that fed the city's water mains. The architect William W. Boyington (1839-1898) designed the water tower and engine house, which is where the iron beams were used.¹⁹⁴ Boyington, with Otis L. Wheelock (1816-c.1886), also designed the Illinois State Penitentiary in Joliet, for which a large quantity of beams was shipped from Trenton in 1861.

Certain architects also spread the system to locations where they received commissions. James Renwick, Jr., designed the Main Building for the newly established Vassar College, on which construction began in 1861. A separate building was constructed for a gas-house and boiler to provide steam heat for the main college building, and it was probably in this building that the iron beams shipped from Trenton were installed.¹⁹⁵ John Notman, who designed one of the earliest American buildings with cast iron beams, ordered angle bar and bar iron to reconstruct the fire-damaged Nassau Hall at Princeton College

¹⁹³ Henry Ericsson, Sixty Years a Builder, p. 154.

¹⁹⁴ Unfortunately, even from drawings and a description of the water works, I can not tell exactly how the beams were used. Reportedly, they were used to make a fireproof roof over the boilers or (and?) the pumping engine. (Civil Engineering and Public Works, Reports of the United States Commissioners to the Paris Universal Exposition, 1867, (Washington: GPO, 1870), p. 30 and illustration); this can be found in Hse. Doc. of 40th Congress 2nd session, serial set 1354.)

¹⁹⁵ Trenton shipped sixteen 9 inch beams to William Harloe, Vassar's contractor, on April 28, 1862. (Elizabeth Daniels, Main to Mudd (Poughkeepsie: Vassar College, 1987), p. 12.)

(1855). Gridley J. F. Bryant probably learned about Treasury's switch to wrought iron beams from his contact in that office in connection with his work on the custom house in San Francisco. His court house for Cheshire County, in Keene, New Hampshire, was partly fireproof: 61 nine inch beams were sent in 1858 to Smith, Felton, the Boston bank vault company, for this building.

Varieties of Fireproof Systems

The most common type of fireproof floor at the time was brick arches, called segmental because of their shallow rise, between iron I beams. These had the disadvantages of being heavy (when the tops of the arches were filled with concrete -- the best practice), consuming much headroom, and requiring tie rods between the beams. Where a scalloped ceiling crossed with bars was considered unsightly, it was covered up with a flat ceiling of lath and plaster, which added to the cost of the building. Several alternatives to the brick arch were introduced. One was stone slabs carried on iron joists. Eidlitz used such a system in his American Exchange Bank and Continental Bank buildings; another building with such floors was the Mutual Benefit Life Insurance Building in Newark, N.J.¹⁹⁶ Probably the main reason for using this system was to avoid the need for a lath and plaster ceiling. Wight describes a building with such floors (he does not name it), where the stones were "carved with tracery patterns to form an ornamental ceiling" and the flanges of the beams were covered with ornamental cast iron plates.¹⁹⁷ This must have made a stunning ceiling, but could not have been an economy. Whether the idea of using stone slabs in this way was borrowed from England, where a system of stone in an iron framework had been used in mills and warehouses and described in building textbooks, is unknown. However, the few American examples of such stone floors were not like the English version; in the U.S. example, the stone was carried on the beam flange to form a ceiling rather than laid on the

¹⁹⁶ Peter Wight, "Remarks on Fire-Proof Construction," p. 104.

¹⁹⁷ Peter Wight, The Brickbuilder vol. 6 (March, 1897), p. 54.

top of the beam, as in England, to form the floor.¹⁹⁸ Another early floor system that may have been lighter than a brick arch, and at any rate would have been faster to construct, was one made of flat, deeply corrugated iron plates covered with concrete. This floor was used in the Bank of the State of New York, at the corner of William Street and Exchange Place -- built c. 1855-56 by J. B. and W. W. Cornell's Iron Works. The framework for the floor of this building consisted of eighteen inch deep girders, which carried ten inch beams on their lower flanges. The beams in turn carried iron plates 1/16 inch thick, with V shaped corrugations, which were fastened to the tops of the girders and to each other. The plates were then filled with concrete. The iron beams used in this floor, like the large girders, were fabricated from rolled plates and channels rather than being solid.¹⁹⁹ This floor system, as well as other examples of construction systems and equipment for fireproof buildings, were featured in an 1857 advertisement for the Cornell brothers' company.²⁰⁰ (Illustration 3-8.) Other New York buildings that reportedly had these floors were the Columbian Insurance building (Frederick Diaper), Bank for Savings, and the Fulton Bank.²⁰¹ John B. Cornell

¹⁹⁸ In England, floors made of iron grids filled with stone were built in the 1820s and 1830s, but apparently were not mentioned by either Eidlitz or Wight in the articles each published in the 1860s. Two earlier floors may have been inspired by the English system. One was a floor made of "cast-iron girders, upon which a flagstone floor is to be laid," which was proposed in 1844 for the War and Navy Offices in Washington, but this building was not constructed. (House report no. 267, 28th Congress 1st session (serial set 445), 1844, appendix A.) The fireproof private library in Paterson, N.J., already described, was to have been built with iron beams and stone floors, but wood plank was substituted for stone. ("Fireproof Library," JFI, cited above.)

¹⁹⁹ Engineering News vol. 50 no. 2 (Sept. 10, 1903), pp. 214-215.

²⁰⁰ In David Bigelow History of Prominent Mercantile and Manufacturing Firms (Boston, 1857), illustrated in John Kouwenhoven, The Columbia Historical Portrait of New York (New York: Harper & Row, 1972), p. 245.

²⁰¹ Peter Wight, "Remarks on Fire-Proof Construction," A.I.A. Proceedings, Dec., 1868, p. 61 and error sheet, and AABN vol. 1 (April 15, 1876), p. 126. The Insurance Building, according to AABN's Chicago correspondent (unnamed, but probably Wight), was at Wall and William Streets. Wight believed the Bank for Savings was the first to have this kind of floor. I can not find out anything about these or the Fulton Bank, except that the Bank for Savings was demolished before 1869.

held several patents, but not for this floor; it seems to have been little used.²⁰²

This was a period of considerable experimentation with girder and beam sections. As an engineer writing in 1903 observed about this time, "curious forms of girder construction were attempted, ... the idea of building up I-shaped girders from the wrought iron shapes then procurable led to examples so strange and so dependent upon faith that the wonder is that they even continued to stand."²⁰³

Architectural Consequences of the New Materials

This was the iron age, architects agreed, and while the use of iron for facades was controversial, few objected to the use of iron structurally. How did the new methods and materials of construction affect the planning of buildings? Interestingly, iron and brick was not very different from wood construction, from the standpoint of planning a structure. A building framed in iron and brick would have had thicker exterior walls and deeper floors, and consequently be much heavier, than a building with a wood interior frame, but the walls of a not very tall building would not have been so much thicker than on an ordinary building to have been noticeable. The system could be built behind any style of facade.

Ammi Young took advantage of the flexibility of the iron and brick system in his federal office buildings. He selected the new Renaissance palazzo style for this federal buildings -- a great novelty, since classical style up to this time been the universal style for

The Chicago correspondent claimed the fire that destroyed the Fulton Bank was one "of no great severity" which may explain why I could not find any accounts of the fire in the New York Times. Beams were ordered from Trenton for a Fulton Bank in 1862. (George Jackson, C&H order book, C&H collection, item 529.)

²⁰² I searched through all likely patent subject categories, pre-1873, and found no floor like this. J. B. Cornell did patent a fireproof floor (no. 22,939) Feb. 15, 1859, but it was a kind of wood floor. Peter Wight wrote that this kind of floor with flat corrugated plates were used in "some instances," which suggests it was not used much. (The Brickbuilder vol. 6 (March, 1897), p. 54.)

²⁰³ J. K. Freitag, "Steel Buildings and Our Steel Industry," Fireproof vol. 3 (Oct., 1903), p. 35.

Illustration 3-9. Corrugated iron plate and concrete floor, illustrated in an advertisement for Cornell's Iron Works. The ad shows Cornell's various products. The iron floor is in the center of the ad.



such buildings.²⁰⁴ The Renaissance palazzo form made a hit when it was used by the English architect Charles Barry in his Travellers' Club House (1829-1832) and Reform Club (1838-41) in London. Interestingly, the Reform Club was partly fireproof, having cast iron beams and brick arches over certain vulnerable parts of the building. Whether or not Young knew of these construction details, I can not say. In laying out his buildings, Young also took advantage of the flexibility of the system by creating open floor plans without having to resort to the interior bearing walls or soaring domes of the vault system. On the other hand, this openness was a cross-purposes with the requirements for fire safety.

One consequence of the new materials for architects was that they had to provide precise construction details. The correspondence of the Supervising Architect's Office in the 1850s is full of problems that occurred because measurements for iron columns were off. The cost of errors when the material was very expensive and could not be reused was substantial. For ordinary buildings, an owner might just select an existing building and order one to be built like it, without providing working drawings.²⁰⁵ Thus, the fireproof buildings probably also forced extra drawings containing construction details.

Iron and Brick Becomes Standard

The building industry was hit hard in the depression that followed the 1857 panic, and then the Civil War came and domestic production nationwide was directed to the war effort. When building construction picked up after the war, the iron and brick system was the

²⁰⁴ Marcus Whiffen and Frederick Koeper, American Architecture 1607-1976 (Cambridge: M.I.T. Press, 1981), p. 201; Daniel Bluestone, "Civic and Aesthetic Reserve: Ammi Burnham Young's 1850s Federal Customhouse Designs," Winterthur Portfolio vol. 25 (Summer/autumn, 1990), pp. 131-156.

²⁰⁵ This was the practice the architect James Gallier found in New York when he arrived in 1832, "... some proprietors built without having any regular plan. When they wanted a house built, they looked about for one already finished, which they thought suitable to their purpose; and then bargained with a builder to erect for them such another, or one with such alterations upon the model as they might point out." Gallier then said architects began to be employed to a greater extent and "the style of buildings ... showed signs of rapid improvement. But while architects may have made more stylish plans and elevations, it is not clear whether, for ordinary buildings, construction details were commonly prepared or whether, for traditionally built structures, much was left up to the builder. (Autobiography of James Gallier (Paris, 1864), p. 18.)

method used for constructing fireproof buildings. But it appears that there was a drop off in fireproof buildings as a proportion of all construction.

One great contributor to this situation was the decline in the number of Treasury Department buildings and the fact that the government's role as technological innovator ceased. After the war, the West Point-trained engineers, who had been so prominent in federal construction in the 1850s, no longer worked on federal buildings. In a remarkable confluence of people and events, the men who had once worked closely on the construction of fireproof Treasury buildings were all uniquely affected by the firing on Fort Sumter. Bowman and Cullum had built Fort Sumter. It was the iron inspector at Trenton, Robert Anderson, who had just been put in command of the federal troops in South Carolina that withdrew to Fort Sumter in 1860, who became its celebrated defender. Meanwhile, Gustavus Smith, the engineer at Trenton, and P. G. T. Beauregard, the superintendent of Treasury construction in New Orleans, both joined the Confederate Army. But even the civilian architect, Ammi Young, was removed from his position as Supervising Architect following false charges of misconduct.²⁰⁶ The Engineer-in-Charge position disappeared and by the end of the war the office was taken over by an politically connected architect with little interest in building technology. The federal buildings constructed in the 1860s for the most part used the technology of the 1850s.

Although private construction recovered after the war, owners were disinclined to build fireproof. This situation puzzled an editorial writer in The Nation in 1867,

²⁰⁶ House of Representatives, report no. 140, 38th Congress 1st session, June 30, 1864. This was one of the many government corruption scandals in the 1860s and 1870s. As far as I can make out, the charges were baseless. The target of the investigation was Spencer M. Clark, who succeeded Bowman as Engineer-in-Charge at Treasury. Clark was later put in charge of a war-time project to transfer printing of currency from private bank note printers to the government. The private printers fought to get the work back. One of their strategies was to ruin Clark's reputation and apparently in this connection, they had their friends in Congress investigate the Office of Construction. The office was accused of various minor faults, intended to make the staff look extravagant and incompetent. As evidence of how absurd the case against the office was, an 1838 report criticizing the construction of Mills' east wing of the Treasury Building was included as an exhibit in the investigation, as if the controversy of 25 years before pertained to Clark or Young. But while Clark was cleared, Young seems to have had no protectors and lost his job.

The American people adopt with great readiness any new method of accomplishing an object of practical utility.... The rapid extension of the street-railways, the almost universal use of the sewing machine, and the liberal ... employment of the telegraph for newspaper purposes, are conspicuous among the developments of the past few years.... To this general rule, however, there are some important exceptions.... And of these the neglect on the part of property owners in large cities to avail themselves of the means...for the protection of valuable buildings and their contents from destruction by fire is one of the least excusable.²⁰⁷

The editorial argued that if the money spent rebuilding after a fire had only been put into fire protection construction in the first place, then destruction of property, business disarrangement, and disruption of streets in the course of rebuilding could be avoided. The means existed -- people had but to study the matter. And they got a very good opportunity to do so at the turn of the next decade.

²⁰⁷ The Nation (April 11, 1867), p. 298.

Chapter 4.

Response to the Great Fires: Experimentation in the 1870s and Early 1880s

Introduction

In the chronicles of great urban conflagrations, the period of the American Civil War, remarkably, is a blank. The loss of property due to fire, apparently, was dwarfed by losses from other causes. Moreover, the fires that did occur -- for example, in Columbia, South Carolina and Richmond -- provided no lessons for students of structural fire protection since these cities did not contain any modern, iron and brick fireproof buildings.

Of the large number of buildings added to the nation's stock in the construction boom that followed the war, very few were fireproof. In Chicago, for example, the population nearly tripled during the 1860s; thousands of buildings were constructed, including large, public buildings such as a jail, Chamber of Commerce building, and college buildings. Yet by the end of the decade, and despite the four large fires in the city in the late 1850s and late 1860s, perhaps ten buildings in Chicago were fireproof.¹ New York continued to be the center of fireproof construction, and the clients for fireproof buildings -- banks, institutions, government, and some especially hazardous businesses -- were essentially unchanged.

Iron and Brick Fireproof Construction Settles In

The small growth in the number of fireproof buildings in the years after the war was not due to a lack of capacity to produce them. Most large cities had foundries capable of making structural castings and some foundries -- notably Daniel Badger's Architectural Iron Works in New York and Hayward, Bartlett, and Company in Baltimore -- served a national market. Several rolling mills, in addition to Trenton and Phoenix works, could supply rolled iron beams. Also, beams were available in a greater range of sizes: by 1868, Buffalo Union,

¹ Elias Colbert and Everett Chamberlin, Chicago and the Great Conflagration (Cincinnati and New York: C. F. Vent, 1872), pp. 145-152, 472-473.

Phoenix, and Trenton Iron Works could supply beams 15 inches deep.² While the iron and brick fireproof system had by this time passed beyond the experimental stage, it was still very costly compared with alternatives and this was probably the main reason that fireproof buildings continued to be rare. Iron could not compete with wood, from the standpoint of initial cost. By one estimate, a fireproof building cost more than double an ordinary one of brick and wood.³

While the most common system of fireproof construction at this time differed little from that introduced in the 1850s, a few inventors tried to improve on the system, by creating lighter and shallower fireproof floors, and by devising methods of making ordinary buildings more fire resistant, if not absolutely fireproof. These innovations can be classified under three headings: methods of creating fireproof barriers under wood floors and roofs; concrete floors; and structural hollow tile.

The first category of inventions -- barriers under ordinary floors and roofs -- was a continuation of the "compartment system" and was intended to improve the fire resistance of ordinary buildings. A long used example of this system was to put an extra thick layer of mortar on a wood floor and cover it with floor boards. Whether this idea or later inventions were inspired by the late eighteenth century British versions of this idea, David Hartley's fire-plates and the Earl of Stanhope's pugging, or later British inventions is unknown; probably the similarities are coincidental.⁴ In 1868, the firm of R. M. Hoe & Co., manufacturers of revolving cylinder presses, tested a method of protecting wood floors for the new plant it was building in New York. The floor was made by fastening iron sheets to the bottom of wood

² R. G. Hatfield, "Fireproof Floors for Banks, Insurance Companies, Office Buildings and Dwellings," Feb., 1868, A.I.A. Proceedings of Second Annual Convention, 1868, p. 8. Phoenix could roll 15 inch beams in 1861. Trenton Iron Works apparently could not roll such large beams in 1864, as it filled a client's order for 12 inch beams with beams it obtained from Phoenix Iron. (July 27, 1864, Order Book, April 1864 - June 1865, Cooper & Hewitt Collection, LC, Manuscript Division.)

³ New York Times, May 16, 1868, 2:5.

⁴ These two systems are described in Associated Architects, Resolutions of the Associated Architects (London, 1793). Other versions of this idea include "silicate slabs" and boards of fibrous plaster, designed to be fixed under, between, and over joists, which were invented by D. Anderson & Son and W. B. Wilkinson, respectively. (John J. Webster, "Fire-proof Construction," Minutes of Proceedings of the Institution of Civil Engineers vol. 12 (1890-91), p. 274.)

joists and spreading a layer of plaster on the sheet and also up the sides and over the top of the joists. Iron sheets were then attached to the top sides of the beams and covered with plaster before the floor boards were laid.⁵ While this floor cost much less than an iron and brick arch floor, it had several drawbacks. Thin sheet metal was a good heat conductor and was prone to warp in a fire; secondly, wood thoroughly encased in plaster was liable to rot; and plaster caused iron to rust. This floor probably was little used by other owners.

Another variation of the barrier idea, which was more successful, was a floor in which the barrier was made of corrugated iron sheets covered with a layer of concrete. This floor was patented in 1867 by a Philadelphia builder, Joseph Gilbert.⁶ The corrugated sheets were either arched, to go under floors made of plank laid on iron beams, or flat, to go under roofs. They were held in place by a cast iron ledge or "bearer" that ran along its bottom flange of the beam and was scalloped like the sheet. In this version, the corrugated plates only made a barrier under the floor or ceiling -- it did not carry any load. Gilbert listed the following advantages of his "cheap, light, and ornamental fire-proof ceiling" compared with an iron and brick floor: it required lighter I beams, since the floor weighed much less; longer spans between beams were possible, therefore less iron was required; the ceiling could be put up quickly; the underside did not have to be finished. He estimated that his ceilings would cost 75 percent of the cost of brick floors.

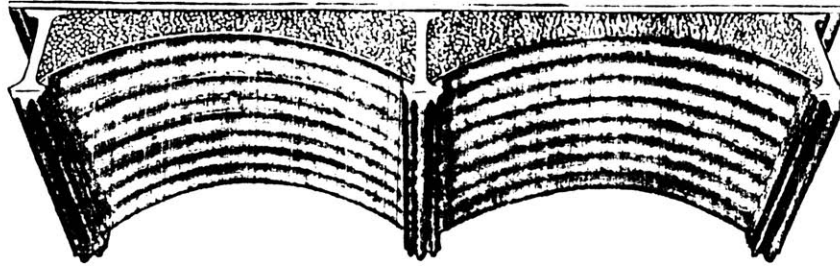
Gilbert's patent also mentions that the space above the plate, to the full depth of the beam, could be filled in with concrete. In this form, the floor was no longer a barrier type but a thoroughly fireproof, concrete floor. Filled solid, the floor actually was a load-bearing, concrete floor, with the corrugated arch serving merely a permanent *centering*. (Illustration 4-1.) In this form, the floor was similar to the Cornell floor used in the Bank of the State of New York (described in the previous chapter). Another inspiration may have been the floor illustrated in William Fairbairn's well-known 1854 book on fireproof construction; the sheets

⁵ New York Times, May 16, 1868, 2:5. Richard Hoe's patent was for a "fire-proof building;" no. 90,361, May 25, 1969. The drawing in the Annual Report of the Commission of Patents for 1969 shows hollow forms placed between the joists surrounded by plaster, intended no doubt to reduce the weight of the filling.

⁶ Patent no. 64,659, dated May 14, 1867; an article about the product in ARABJ vol. 1 (July, 1868), pp. 60-67.

in this floor were arched but not corrugated.⁷

Illustration 4-1. Gilbert floor, cross section. This was a corrugated iron arch filled with concrete.



Probably the Cornell floor was the only other concrete floor in use in the U.S. by this time and consequently few Americans had any direct knowledge of how concrete performed in tension, as in these floors. To prove to others that his load-bearing concrete floor would work, Gilbert allowed it to be tested by the author of a popular engineering textbook, John C. Trautwine, Jr., and other authorities. A sample of the floor made of sheets of "18 gauge" iron, six feet span and 28 inches wide, supported a six ton load.⁸ Gilbert's floor also was examined and endorsed by a committee of the Franklin Institute, and its report also was endorsed by Philadelphia architects, several of whom -- e.g., Frank Furness, George W. Hewitt, and John McArthur, Jr. -- were construction experts and designed fireproof buildings.

This style of floor enjoyed some popularity for a time, especially in Chicago, where most of the fireproof buildings had these floors rather than brick arches. Union Foundry

⁷ An 1868 article about Gilbert's floor quotes Fairbairn on the merits of this floor, showing that Gilbert knew Fairbairn's book. (ARABJ vol. 1 (July, 1868), pp. 65-66.) But the beams in Fairbairn's floor were three feet apart. Those in the Cornell floor, as used in the Bank of the State of New York, and in Gilbert's floor, were about 6 feet apart, which may be a coincidence or may show that Gilbert was familiar with Cornell's floor. (Engineering News vol. 50 (Sept. 10, 1903), p. 222, and ARABJ vol. 1 (July, 1868), p. 67.) Corrugated iron arches also were used in England in a system introduced by Richard Moreland, according to John J. Webster, although Webster does not say when Moreland's system became available. ("Fire-proof Construction," p. 264.)

⁸ ARABJ vol. 1 (July, 1868), p. 67.

Works in Chicago was licensed by Gilbert to make his floors.⁹ Following successful tests of the floor at this foundry, the developers of the Tribune Building had them installed in their new building (1868-1869).¹⁰ The other Chicago buildings with these floors were the First National Bank c. 1868, like the Tribune, designed by Edward Burling; the new wings of county court house; Nixon Building (c. 1871, Otto Matz); and the ground floor strong room of Fidelity Safe Deposit Company.¹¹

Another firm that supplied iron for and also built corrugated iron floors was George Dwight, Jr. & Company of Springfield, Massachusetts.¹² Some of the floors of the Equitable Life Assurance Co. building in New York (1868-70, designed by Arthur Gilman (1821-1882) and Edward H. Kendall (1842-1901), with George B. Post (1837-1913) as consulting architect), were made of corrugated iron arches furnished by Dwight's firm.¹³ The U.S. Court House and Post Office in New York also was one of Dwight's projects: in 1874, his firm supplied arched iron sheets that were used to make concrete arches under the roof of the

⁹ Information that Union Foundry Works was licensed by Gilbert, from Peter Wight, AABN vol. 1 (Aug. 5, 1876), p. 255.

¹⁰ Chicago Tribune, May 28, 1868, quoted in ARABJ vol. 1 (July, 1868). Union Iron Mills of Pittsburgh furnished the rolled joists for this building.

¹¹ AABN vol. 1 (April 15, 1876), p. 126. Philadelphia Architectural Iron Company, which was licensed to make these floors, lists the First National Bank as one of its customers. Philadelphia Architectural Iron Company (Philadelphia, 1872), trade catalogue in the collection of NMAH. Source for the wings of the court house and Fidelity Safe Deposit Co. building, George Dwight, Jr. in AABN vol. 1 (July 8, 1876), pp. 222-223. According to Dwight, only the first floor of the Fidelity Safe Deposit Company building had corrugated iron and concrete floors. The wings of the court house were built after the Civil War (Frank Randall, History of the Development of Building Construction in Chicago (Urbana: University of Illinois Press, 1949), p. 38.) Of the Nixon, Henry Ericsson writes that it had corrugated iron ceilings, "the same as the Tribune Building." (Sixty Years a Builder (New York: Arno Press, 1972), p. 206.) Although other sources say the building had brick arches, I am inclined to think Ericsson is correct. (For example, see Frank Randall, History of ... Building Construction in Chicago, p. 61; and The Great Conflagration, p. 100.)

¹² George Dwight, Jr., & Co. was the successor to American Corrugated Iron Co., Iron Builders, of Springfield. Its 1874 letterhead listed these products: fire-proof shutters, galvanized iron work, fire-proof floors, roofs and trusses, and corrugated iron. (Letter dated May 23, 1874 in NA, RG 121, entry 26, New York Post Office, box 313.)

¹³ George Dwight obituary, The Springfield Republican, Jan. 3, 1909. (Thanks to Maggie Humberston of the Connecticut Valley Historical Museum.) A History of Real Estate, Building and Architecture in New York City (New York: Arno Press, 1967), reprint of 1898, pp. 379-382 and 595 (on Post's role). J. B. and J. M. Cornell of New York City were the iron contractors on the Equitable building, but apparently their own version of a corrugated iron was not used in this case.

building.¹⁴ In Boston, the ten story building of the Equitable Life Co. (1873-1877), like their New York building, had iron floors filled with concrete.¹⁵

At this time, a number of concrete floor systems, both *reinforced* and unreinforced, were in use in France and Great Britain and while some American architects were acquainted with the French and British systems, they do not seem to have tried them.¹⁶ There are hints that building products made of concrete were available in the U.S. in the 1860s. "Artificial stone," which was a name for concrete, was manufactured by the Missouri Concrete Stone Co., for example, for "bridges, gateways, mantels, vases, tiles, grave stones and every variety of ornamental work."¹⁷ Four presses for making concrete building blocks were patented in 1868, all by mid-Western men.¹⁸ A New York company, the New-York Stone Works, listed among the products on its letter-head in 1869, "floors, all in one piece, for breweries, factories, and private houses, &c."¹⁹ These may have been concrete surfaces over some other type of floor structure (i.e., a waterproof, fire resistant surface without cracks over a wooden floor), not bearing floors. None of the contemporary experts on fireproof construction ever indicated that there were such floors in the U.S.

Tantalizing as these hints are, the reason we can be fairly sure that concrete was not being used in the U.S. at this time to any large extent for structural purposes, was that an

¹⁴ The roof was a mansard style, which was widely condemned after the Boston fire of 1872. The roof, as ordinarily framed, contained a great amount of wood members of small dimension, which burned rapidly. Architects and materials manufacturers tried to devise ways to build this style of roof -- which was still extremely popular in the 1870s -- safely. Mullett's solution was to create a fireproof barrier with corrugated iron and concrete arches. However, the arches were too heavy for the supports and helped bring down the roof. (See, for example, Engineering News (May 19, 1877), p. 125.)

¹⁵ From a description in John E. Whiting, A Schedule of Buildings...in the City of Boston (published for the use of insurance companies, 1877). This building was at 146-162 Devonshire Street.

¹⁶ For example, the fireproof construction Nathaniel Hutton recommended in an 1873 paper was largely based on concrete: concrete walls, floors, roof, even stairways. However, he was making a proposal only, ("Fire-Proof Construction," AABN vol. 1 (Feb. 5, 1876), p. 44.)

¹⁷ Missouri Concrete Stone Co. (Saint Louis, 1867), trade catalogue in the collection of Missouri Historical Society. This company used the process patented by the English artificial stone manufacturer, Frederick Ransome. Thanks to Emily Miller, librarian at the Society, for copying part of this catalogue for me.

¹⁸ Patent no.s 73,600; 77,854; 82,301; and 85,291.

¹⁹ Letter to A. B. Mullett, September 9, 1869, NA, RG 121, entry 6, New York Post Office and Court House, 1869.

important ingredient in structural concrete, hydraulic cement or lime, was very expensive here. Unlike in Britain, where "*Portland*," also called "artificial," cement was invented and produced in quantities, or in Paris, where a kind of plaster that worked well structurally was available in abundance, suitable adhesive materials in the U.S. were scarce. Domestic hydraulic cement or lime, and Portland cement imported from Britain and Germany, were costly products. The large use of concrete awaited increased domestic production of Portland cement.

The third category of new inventions -- structural hollow tile -- was represented by a single example. This was a tile used to build the first floor of the fireproof Cooper Institute building in New York City in the 1850s. It was patented by the building's architect, the German immigrant Frederick A. Peterson (1808-1885).²⁰ Unlike the pots, tubes, and hollow blocks used in England and France by mid-century, Peterson's tile was a very large block -- nearly two and a half feet wide -- designed to span between iron beams. It had an arched top and flat bottom and was formed by hand of semi-*fire-clay* (fire-clay is a special kind of clay found at greater depths than ordinary brick clay). While the beams in the patent drawing appear to be cast iron, the floor that was actually built had T shaped beams made of pairs of six inch channel bars.²¹ Where Peterson got this idea is unknown. Although this tile was not a commercially viable product, structural hollow tile was to become extremely important in fireproof construction, as will be discussed shortly.

None of these inventions were either significant improvements over, or cheaper than, iron and brick floors. Consequently, they did not have the effect of increasing the number of fireproof buildings.

There was one other invention in this decade that was used in a few fireproof buildings, although its principal used was in bridge construction. This was a column made of wrought iron, patented in 1862 by the Phoenix Iron Company.²² It was probably the first

²⁰ Patent no. 12,642, April 3, 1855.

²¹ Described by Peter Wight, an experienced tile manufacturer, who inspected the tiles when the building was renovated. (*The Brickbuilder* vol. 6 (March, 1897), p. 54.)

²² Patent no. 35,582 by Samuel J. Reeves, June 17, 1862.

instance of rolled iron being used as a column. The universal material for columns up until this time was cast iron; however, cast iron was already developing a bad reputation. One problem was the difficulty of inspecting hollow columns for casting flaws. A notorious accident in 1860, the collapse of a large mill in Lawrence, Mass., was attributed partly to defective columns.²³ In addition, there were manufacturing limitations to the size of cast iron columns, a problem the Phoenix column could overcome.

The Phoenix column was a tube formed by riveting specially shaped, flanged sections -- four or more -- together.²⁴ (Illustration 4-2.) One early building with these columns was the Public Ledger Building in Philadelphia, designed by John McArthur, Jr. (1823-1890) and completed in 1867. The Ledger Building was described by a contemporary as "partially" fireproof, so presumably only the lower floors, containing the publisher's valuable and heavy printing presses (manufactured by the same R. Hoe & Co. that was trying to make its own buildings more secure), were fireproof and supported by Phoenix columns.²⁵ The columns in this building were made extra strong by adding a plate of iron at the joint between the column sections; these plates extended up over the top of the column and facilitated connecting the column to the beams. Another place where these columns were used was in the basement level of the fireproof store built by Samuel White a few blocks west of the Ledger Building in Philadelphia (already described). Phoenix also supplied the iron girders and beams used in this building.²⁶ The Phoenix column were used in buildings to a larger extent later in the century.

While the federal government continued the policy of constructing its buildings

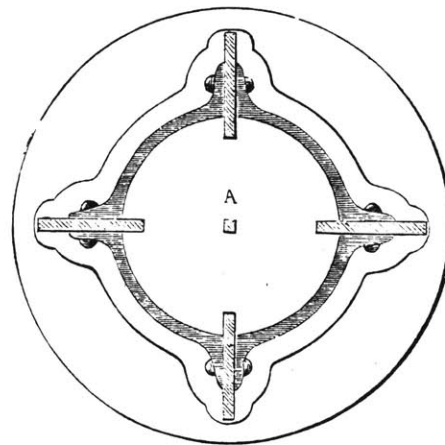
²³ New York Times, Feb. 5, 1860, p. 5.

²⁴ Alan Burnham, "The Rise and Fall of the Phoenix Column," Architectural Record (April, 1959), pp. 222-225; Christopher Baer, "Phoenix Steel Corporation," Hagley Museum and Library, Manuscripts and Archives department.

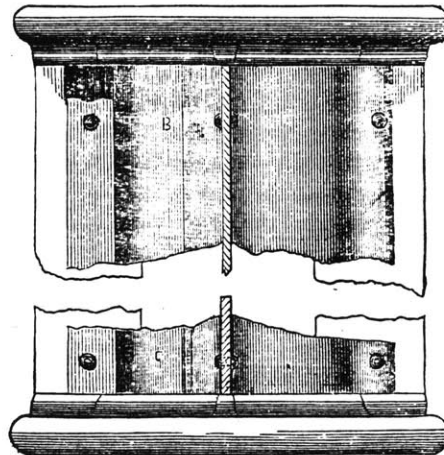
²⁵ Peter Wight, "Remarks on Fire-Proof Construction," ARABJ vol. 2 (August, 1869), p. 102. Burnham quotes the owners of the building as saying that the columns were in "an underground apartment" -- presumably the basement floor. ("Rise and Fall," p. 224.) The Public Ledger and the Sun were owned by the partners Arunah Abell, Azariah Simmons, and William Swain. The Sun was built by Arunah Abell, who built a pioneering fireproof building for the Sun in Baltimore. Date of the building from J. Thomas Scharf and T. Westcott, History of Philadelphia 1609-1884 (Philadelphia: L. H. Everts & Co., 1884), p. 2006.

²⁶ Sloan's ARABJ vol. 1 (August, 1868), pp. 90-94.

Illustration 4-2. Phoenix columns, section and elevation.



No. 4.



fireproof, the Treasury Department's Office of Construction abandoned its role as innovator and clearing house for new construction ideas. When the war began, the Engineer-in-Charge at the time, William Franklin, left to fight. The position disappeared and the Army Corps of Engineers officers were never again involved with federal civilian construction projects as they had been in the 1850s. From about 1866 to 1874, the office was headed by the controversial architect Alfred B. Mullett (1834-1890), who took over the functions of both the Engineer-in-Charge and Supervising Architect. He completely altered the design priorities of the office. Instead of technologically advanced buildings with simple facades, he designed

ornate French Second Empire style buildings with what were, by this time, technologically conservative interiors. Mullett adopted some of the new materials that came on the market, but he neither sought out nor encouraged innovation through government procurement. For the rest of period of this study, the federal government was a follower, not a leader, of developments building construction.

To track where and what kind of buildings were constructed fireproof in the 1860s, besides those of the federal government, Trenton Iron Works' business records are once again a prime source of information. It was still the case that practically every building with iron beams was fireproof.²⁷ Banks and institutions continued to be the main customers for fireproof buildings, but in the 1860s, insurance companies also began to build fireproof. Among the projects built with Trenton's beams were the Mutual Life Insurance Company building (c. 1863-1870) in New York and the infamous New York County ("Tweed") Court House (1861-1872), both designed by John Kellum (1809-1871). The building of the Metropolitan Gas Works, at the North River end of 42nd Street, which received a large order of 20 foot long, nine inch beams in early 1861, was considered by the same writer as one of the best of the fireproof gas work buildings in New York.²⁸ Other projects outside of Manhattan include the Glenham Company in Fishkill, New York, to which a large number of beams was shipped in 1865; Hupfels Brewery in the Bronx (shipment in 1865); Kings County (Brooklyn) Court House, by Gamaliel King and Herman Technitz, completed in 1865.²⁹ Trenton beams were used in the Historical Society building (1866) in Chicago, built from

²⁷ One of the few buildings with iron beams that was not fireproof was the well-known A. T. Stewart store at Broadway and 9th Street (c. 1859-64), in which a huge number of iron beams was used. The floors of this building were wood and it was never described by contemporaries as a fireproof building. William Starrett, the prominent builder and historian of skyscrapers, described it as "thoroughly fireproof according to the best traditions of the early '70s." (*Skyscrapers and the Men Who Build Them* (New York: Charles Scribner's Sons, 1928), p. 23) But he is mistaken about this. Perhaps it was not built fireproof because the walls, which were of iron on all four sides, could not have supported brick floors (which, in a building as large as this, would have been extremely heavy).

²⁸ Peter Wight, "Remarks on Fire-Proof Construction," pp. 101-102.

²⁹ I am not able to confirm that the Glenham Company or Hupfel buildings were fireproof, but the large number of beams shipped suggests that they were. Kings County Court House was, by contemporary accounts, fireproof.

plans by (Edward) Burling & Co.³⁰ Also in Chicago, the pumping house of Chicago's celebrated North Side waterworks, designed by William W. Boyington and Otis L. Wheelock (and built in the previous decade, c. 1858), had Trenton beams.³¹

Other fireproof buildings use rolled iron from other suppliers, more evidence that by the 1860s, Trenton had ceased to dominate the beam market even in New York City. Griffith Thomas designed the Park National Bank at 214-216 Broadway and New York Life Insurance Company building at Broadway between Leonard and Catherine Streets (1868-70), the latter on the site of buildings destroyed by fire in 1867.³² (Illustration 4-3.) These two buildings along with the renovation of City Bank in Wall Street, by Robert G. Hatfield and St. John's Depot of the Hudson River Railroad Company, were considered notable fireproof buildings.³³ John Kellum's Women's Home, built by the dry goods magnate, A. T. Stewart, as a residence for working women but soon turned into a regular hotel, was fireproof.³⁴ The Columbia Insurance Building, by Frederick Diaper, had corrugated iron arches, presumably like the Gilbert arch.³⁵

Outside of New York, James Renwick's art gallery for William Corcoran in Washington, D.C. -- largely complete by 1861 when it was commandeered for war purposes - - was fireproof. Boston's new City Hall, designed by Gridley J. F. Bryant with Arthur Gilman, which finally got underway after much legislative squabbling in 1861, had wrought iron beams and brick arches through most of the building. The wrought iron beams were

³⁰ The Tribune wrote of the Chicago Historical Society building (Nov. 20, 1868), "The building is fireproof, with floors of iron beams and a brick arch finished with marble tiling, and a metal roof frame work." (Paul Angle, The Chicago Historical Society 1856-1956 (New York: Rand McNally & Co., 1956), p. 44.)

³¹ "Memorial to the Late W. W. Boyington," IA vol. 32 (Nov., 1898), p. 32.

³² Asher & Adams, Pictorial Album of American Industry 1876 (New York: Rutledge Books, 1976), reprint of 1876, p. 35.

³³ Hatfield obituary, AABN vol. 5 (March 1, 1879), p. 166; Peter Wight, "Remarks on Fire-Proof Construction," p. 100; History of Real Estate...in New York City, pp. 379, 595, and 615.

³⁴ Construction on this building began in 1870. Its facade was manufactured by J. B. and W. W. Cornell. (History of Real Estate...in New York City, pp. 461 and 616, and Architectural Record vol. 1 (1891), p. 245.)

³⁵ Peter Wight, "Remarks on Fire-Proof Construction," p. 104.

Illustration 4-3. New York Life Insurance Co., New York (1868-1870)



THE COMPANY'S BUILDING, 346 and 348 BROADWAY, NEW YORK

made by Phoenix Iron Company.³⁶ In 1865, a fire burned the wood roof over the central part of the Smithsonian building in Washington. It got a new iron roof, supplied by Phoenix Iron Co., and building's five towers were fitted with iron and brick floors.³⁷ Besides the Chicago buildings already mentioned, an example of a fireproof building in the West was

³⁶ The City Hall, Boston, p. 111. The facade is the work of Bryant and Arthur Gilman.

³⁷ Adolf Cluss, "Report of the Architects for the Reconstruction of the Eastern Portion of the Smithsonian Institution," Annual Report of the Board of Regents of the Smithsonian Institution for 1884 (Washington: G.P.O., 1885); Robert Esau, "Fear of Fire; An Investigation into the Fireproofing of the Smithsonian Institution Building," Smithsonian Institution, Aug 10, 1990.

Cleveland's City Hall, c. 1870, which had "floors resting on iron beams with brick arching."³⁸ In Philadelphia, the store built c. 1867 by Samuel White, maker of artificial teeth (previously mentioned) was fireproof, although its details were novel. Probably to save weight, the upper floors in this building were not the usual brick arches filled with concrete, as was the first floor. These upper floors were built of wrought iron girders, nearly 28 inches deep, which spanned about 40 feet from side wall to side wall; they were about 8 to 10 feet apart. Brick arches were built between the girders and rather than filling the tops with concrete, little "walls" were built on top of them. These "walls," spaced six feet apart, essentially took the place of joists; they carried three by four inch planks which were then covered with floor boards.³⁹

But Were They Fireproof?

The iron and brick system defined fireproof construction and Americans took for granted that the system would perform as advertised. In the few published works written by Americans from this time that dealt with fireproof construction, a fireproof building was one with floors made of rolled iron beams and brick arches. These include Robert Hatfield's 1868 paper on fireproof floors, prepared for the American Institute of Architects (A.I.A.), and Peter Wight's 1869 paper read to the New York chapter of the A.I.A. and reprinted in Sloan's Architectural Review and American Builders' Journal (ARABJ).⁴⁰ In Britain, on the other hand, where iron and brick buildings had been destroyed in fires, architects were no longer so sure. As early as the 1840s, James Braidwood, Superintendent of the London Fire-Brigade, cautioned about iron as a building material. He argued that cast iron beams and columns, when used in large buildings with open floor areas, open staircases and shafts, and filled with combustible goods, "are not, practically speaking, fireproof." Cast iron, he warned, was liable to fail for many reasons, including flawed casting or weakness from over-loading; iron girders expanded at high temperatures and could push out walls; iron tie rods may yield when softened in a fire and let down the floors; and heated cast iron may fracture when cold water

³⁸ ARABJ vol. 2 (1870), p. 699. The winning design was by Heard and Blythe of Cleveland.

³⁹ Description in ARABJ vol. 1 (August, 1868), pp. 90-94.

⁴⁰ R. G. Hatfield, "Fireproof Floors for Banks, Insurance Companies, Office Buildings and Dwellings," Feb. 1868, and Peter Wight, "Remarks on Fire-Proof Construction."

was thrown on it. "For these and similar reasons," he explained, "the firemen are not permitted to go into warehouses supported by iron, when once fairly on fire."⁴¹

Braidwood was killed in 1861 when a wall collapsed on him while he was fighting London's worst conflagration since 1666, the Tooley Street fire. The fire started in and spread among the very iron warehouses that he and his men dreaded entering. It seemed to many that Braidwood's cautions about iron were justified, leading them to conclude that iron and brick buildings actually were less safe than buildings with wood interior frames.⁴² One of the people in this camp was Braidwood's successor, the redoubtable Capt. Eyre M. Shaw. Rather than iron and brick, he recommended an interior frame made of hardwood posts, wood girders and joists, the space between to be filled with cement.⁴³ Such a frame, at any rate, would not fail without warning, as he believed iron frames did. He condemned the use of stone for building and especially for constructing stairways as was routinely done in London - - ironically, to satisfy the fire safety requirements of the Building Act -- because of its tendency to fracture and spall in a fire. He objected to hollow brick because it might explode when heated.⁴⁴ Shaw was skeptical of the whole idea of fireproof construction and ignored the subject in his fire protection handbook, Fire Surveys.⁴⁵ His solution to the problem of structural fire safety was to limit size of buildings -- cubical capacity as well as height -- rather than try to make buildings "fireproof." Revered as a hero, even immortalized in a song by Gilbert and Sullivan, his views were cited and adopted by many writers in the architectural press for years to come. For example, the architect T. Hayter Lewis asserted in an 1865 paper, "Nothing short of diminishing the size of warehouses and other such buildings, or protecting them with brick arches or brick piers [as in solid masonry buildings], will render them secure; ...the common method of brick arches on iron girders is the most dangerous that

⁴¹ James Braidwood, Fire Prevention and Fire Extinction (London: Bell and Daldy, 1866); quote, p. 48.

⁴² For example, B. H. Thwaite, Our Factories, Workshops, and Warehouses (London: E. & F. N. Spon, 1882), p. 207.

⁴³ From Building News vol. 12 (Jan. 27, 1865), p. 69, and also in, for example, Shaw, Fire Surveys, p. 43.

⁴⁴ Building News vol. 22 (March 29, 1872), p. 250.

⁴⁵ E. M. Shaw, Fire Surveys (London: Effingham Wilson, 1872). This book went through several editions.

can be used."⁴⁶ London's building laws did follow this approach of limiting building size rather than mandating fireproof construction.

In fact, by the 1860s, British architects had largely abandoned brick arches in favor of other fireproof floor systems, most of which used concrete -- often plain concrete in the form of arches, which avoided iron even for reinforcement. These floors could be made with wider spans than the brick arch floors, and therefore could cover rooms from wall to wall and thereby also avoid cast iron columns. The concrete floor system also could be less expensive than iron and brick arch floors. These developments led one architect to exclaim, "What changes have not come over the meaning of fire-proof! Among my early experiences no building was considered fire-proof that had not iron joists and brick arches. ... Now it is generally admitted that no floor can be called ... fire-proof that has iron used in its construction--such is the present position of iron." Indeed, this writer argued, echoing Capt. Shaw, that the idea of a fireproof building was a delusion and suggested the term "fireproof" be replaced with "fire resisting." If iron was used, it had to be properly encased to protect it from heat.⁴⁷ But iron and brick fireproof construction continued to be used in mills and warehouses, and the iron in these buildings continued to be unprotected.

Some American architectural writers repeated their British colleagues' criticisms of iron. For example, in an article in *ARABJ*, a writer stated that the destruction of structural iron in warehouse fires proved that "iron is unreliable as a building material" and could not be an ingredient in a fireproof building.⁴⁸ What this writer, agreeing with Capt. Shaw, recommended instead was wood "rendered incombustible at no great expense" and the British concrete systems, even though they probably were unavailable in the U.S. American engineers, too, were wary of iron, mainly because it expanded when heated and rusted. For example, all of the members of Polytechnic Club in New York at an 1860 meeting whose

⁴⁶ *Building News* vol. 12 (April 7, 1865), p. 244.

⁴⁷ *Building News* vol. 22 (March 29, 1872), p. 250. It was not until this time, the early 1870s, that the need to protect iron fully was appreciated. The first design of a casing to cover iron girders reportedly dates from 1873, when the architect John Whichord designed a tile casing and used it in the National Safe Deposit Co. building in England. (B. H. Thwaite, *Our Factories*, p. 210.)

⁴⁸ "Fire-Proof Construction," *ARABJ* vol. 2 (March, 1870), p. 500.

comments were recorded, following an address about iron front buildings, objected to iron as a building material, although one, at least, acknowledged that the available information on the expansion of iron was poor.⁴⁹

Although some engineers and anglophiles had their reservations, most architects here were satisfied with American fireproof building methods. The Commissioner who reported on building materials and methods of construction at the Universal Exposition in Paris in 1867 found nothing remarkable among the exhibits there, with the exception of the extremely large-sized solid rolled girders and the concrete. He did note approvingly the widespread use of iron, bricks, and concrete in the buildings in Paris, which he believed resulted in "comparative freedom from destructive fires" and the "remarkably cheap" insurance there.⁵⁰ Another Commissioner, Abram Hewitt, was less impressed with French fireproof building technologies, "Thus far the construction of a fire-proof building in the United States is accomplished with less pounds of iron for a given strain per square foot than in France, and we have nothing to learn from the Exposition in this respect."⁵¹

But the fact was, no one knew whether American iron and brick buildings would perform as intended because, with so few of them in existence, they had rarely been put to the test.⁵² One that had been tested was Ammi Young's 1854-58 custom house in Portland, Maine, which was in the path of a fire that destroyed the city center on July 4, 1866. Portland, according to a contemporary account, was considered so sturdy, and had avoided conflagration for so long, that "although insurance rates were unreasonably low, in comparison with rates elsewhere, very few of our people had more than a third or half insurance" and many carried none at all. Even so, individual building fires were not

⁴⁹ Architects' and Mechanics' Journal, vol. 2 (May 5, 1860), p. 42.

⁵⁰ James Bowen, "Report upon Building, Building Materials and Methods of Building," Reports of the United States Commissioners to the Paris Universal Exposition, 1867, vol. IV (Washington: G.P.O., 1870), p. 32.

⁵¹ Abram Hewitt, "The Production of Iron and Steel in Its Economic and Social Relations," Paris Universal Exposition, 1867, Reports of the United States Commissioners, New York, 1870, p. 7.

⁵² According to fireproof building expert Peter Wight wrote, "Before 1871 there were few occasions of disastrous fires to prove the inefficacy of ... simply substituting iron for wood." He only knew of two fireproof buildings that had burned: Singer Sewing-Machine Company, illustrated in Daniel Badger's catalogue of 1865, and the Fulton Bank Building, both in New York. Peter Wight, "Fireproof Construction and the Practice of American Architects," AABN vol 41 (Aug. 19, 1893), p. 113.

unknown. In fact, Young's custom house was built to replace one that burned down in 1854 and with it the collection of the Portland Society of Natural History, which was housed in the building. The Independence Day fire was believed to have started when a firecracker ignited a wood pile on the city's harbor front; Portland's downtown quickly became a "perfect sea of flames." And yet, the new custom house survived this conflagration: it even sheltered a claims agent trapped inside.⁵³ Undoubtedly, outside of Portland and Treasury headquarters in Washington, no one knew the details of how well the custom house withstood the blaze or why it was taken down.⁵⁴

With so few fireproof buildings even available for field testing, so to speak, it was hardly possible for anyone in the U.S. to make structural fire protection a subject of systematic research. Even if someone had taken up the study, there were limited venues for publicizing findings. The few American magazines aimed at architects ceased publication during the Civil War.⁵⁵ The only national professional organization for architects, the A.I.A., was dormant at the time of the Portland fire and the American Society of Civil Engineers (A.S.C.E.) likewise was inactive until the late 1860s.⁵⁶ The great fires in Chicago and Boston came at a fortuitous time for the progress of structural fire protection since they occurred when the professional societies had resumed their national meetings and were publishing proceedings. In addition, in 1876 the first long-lived national architectural periodical, the weekly American Architect and Building News (AABN), began publication. A number of architects became specialists in using the new construction materials by then, and

⁵³ John Neal, Account of the Great Conflagration in Portland, July 4th & 5th, 1866 (Portland: Starbird & Twitchell, 1866), pp. 5, 7 and 26.

⁵⁴ The 1857 custom house was demolished because of extensive spalling of its granite facade. Although it could have been repaired, Alfred Mullett, the Supervising Architect of the Treasury Department at the time, preferred to replace it with one of his signature French Second Empire buildings. As evidence of his lack of comprehension of structural fire protection, he built the facade of the new building out of granite. (AABN vol. 7 (Jan. 31, 1880), p. 33.) This custom house (1868-71) is still standing.

⁵⁵ The Crayon, an arts magazine, carried news of, and published some papers given at, the meetings of the A.I.A., but it ceased publication during the war. Likewise, the short-lived Architectural Review and American Builders' Journal stopped during the war. Neither started up after the war.

⁵⁶ Richard Levy, "The Professionalization of American Architects and Civil Engineers, 1865-1917," PhD dissertation, University of California/Berkeley, 1980, chapter 2. The A.I.A. began to hold annual conventions in 1867. (A. J. Bloor, "History of American Institute of Architects," IA vol. 16 (October, 1890), pp. 40-42.)

some even began to make structural fire safety a specialty.

The Great Fires of Chicago and Boston

Just as the Tooley Street fire taught the British what could happen to iron in blaze, the Chicago conflagration of October, 1871 was a font of lessons for American architects. The fire consumed a huge portion of the city and, by a contemporary estimate, left roughly 100,000 people homeless. Chicago had suffered several serious blazes in the preceding two decades. The great fire was just one more fire, but one that got out of control because of an unfortunate conjunction of circumstances the most consequential of which was the drought conditions in the city. Rainfall in the region was well below normal -- Chicago had gotten only 2 1/2 inches of rain through the summer and fall -- and this wooden city was tinder dry.⁵⁷ In fact, on the same day Chicago burned, a fire also struck a lumbering area around Peshtigo, Wisconsin, near Green Bay. The Peshtigo fire killed over 1,000 people, a much greater loss of life than in Chicago, and was one of the deadliest in U.S. history, while the Chicago fire was one of the costliest.⁵⁸

As mentioned above, a few -- perhaps ten -- of Chicago's buildings were fireproof, and it seems that Chicagoans had great faith in these buildings. Even though the conflagration was so ferocious that no building, even a fireproof building, could reasonably have been expected to withstand it, still locals were dismayed that the "so-called" fireproof buildings were ruined in the blaze. The public seemed to believe that a building called "fireproof" should be absolutely invulnerable. Thus, the Tribune reporters worked away at their desks while the city burned around them, trusting that the fireproof Tribune Building would protect them.⁵⁹ They were finally driven off when the window glass snapped from the heat; their building was badly damaged. Even so, Chicago's few fireproof buildings did not succumb easily. As a witness described the struggle put up by Ammi Young's post office and custom house,

⁵⁷ Elias Colbert and Everett Chamberlin, in Chicago and the Great Conflagration (Cincinnati and New York: C. F. Vent, 1872), write that the 2 1/2 inches of rainfall was 6 1/4 less than normal.

⁵⁸ Arthur Cote, ed., Fire Protection Handbook 17th edition (Quincy, MA: National Fire Protection Association, 1991), p. 1-9.

⁵⁹ Henry Ericsson, Sixty Years a Builder, p. 203.

...for a time, the solid walls of the post office presented a barrier (to the fire). Thwarted here, the flames spread down Clark ... and then, turning Madison, came up the south line of the street like a whirlwind and, turning Dearborn, melted away Reynold's block almost immediately, bringing them to the north side of the post office; while another column ... attacked it on the west side. Before this joint attack, (the post office) yielded.... Although its walls stood bravely, its interior was soon gutted.⁶⁰

Moreover, although they were damaged, many of the fireproof buildings were still standing after the fire -- First National Bank, court house wings, the Nixon, the Fidelity Safe Deposit strong room -- while their neighbors were mere heaps.⁶¹ The Tribune Building was badly damaged because the walls gave way, not the floors. In fact, apparently where the walls survived, the floors were in good condition.⁶²

The Chicago fire occurred a few weeks before the annual convention of the A.I.A. and was a hot topic at the meeting. Peter B. Wight (1838-1925), a New York architect with a longstanding interest in fire protection, visited the burned district three weeks after the event and gave a report on the performance of the fireproof buildings.⁶³ Wight attributed the destruction of the post office to the failure of the cast iron columns: he believed that internal structure collapsed because the columns on the first floor gave way (rather than the beams giving way and dropping the floors, which in turn broke the columns).

Although he blamed the columns, Wight noticed that the lower flanges of beams sagged. He commented that it "may be proper to cover beams with cement, artificial stone, or terra cotta, or plaster." This was a key insight and formed the basis for the next phase of fireproof construction, in which buildings were constructed so as to resist the effect of heat

⁶⁰ James W. Sheahan, The Great Conflagration (Chicago: Union Publishing Co., 1872), p. 77.

⁶¹ Part of the court house was so little injured that it was repaired and used temporarily. (AABN vol. 1 (April 15, 1876). p. 126.) Source on the Fidelity Safe Deposit Co. building: George Dwight, Jr. in AABN vol. 1 (July 8, 1876), pp. 222-223. Dwight wrote that a Newfoundland dog inside this building survived the fire. Likewise, the safe and vaults of First National Bank were unharmed. This building was rebuilt so quickly (it was "rebuilt in December" of 1871) that the structure must have been reused. (Frank Randall, History of the Development of Building Construction in Chicago, p. 48.)

⁶² AABN vol. 5 (May 31, 1879), p. 172. In Was this fire, presumably in the late 1860s, a turning point in the use of corrugated iron arches? They were used less and less in the 1870s. One late example of the system was the Seth Thomas Clock Co. at Thomaston, Conn., built by the Berlin Iron Bridge Co. in 1880. (The Berlin Iron Bridge Co., East Berlin, Conn., trade catalogue, no date, in collection of NMAH.)

⁶³ Peter Wight on the fire at Chicago, A.I.A. Proceedings of the Fifth Annual Convention, 1871.

rather than to be merely noncombustible.

The shoddy construction practices in Chicago were also to blame for the destructiveness of the conflagration, Wight believed; such a fire could never happen in well-built cities like New York or Boston. But by another unlucky confluence of circumstances, the very next year (November, 1872), the "colossal business structures" of Boston were attacked by the "Fire-fiend."⁶⁴ The great villain of the Boston fire was the Mansard roof, which was popular both with architects, who considered it beautiful, and owners, because it functioned more like a slightly sloping wall than a roof. However, unlike a masonry wall, it was a wood frame covered with a thin layer of roofing material. The fire was believed to have spread along the roofs; it reduced the stoutest looking buildings to piles of rubble. Since this fire occurred in the downtown area, few households were left homeless, but property loss was considerable. By one estimate, eight percent of the total value of property in the state was wiped out in the fire.⁶⁵

Architects again tried to draw lessons from the devastation. At the A.I.A. meeting in 1872, members offered many observations and recommendations. Robert G. Hatfield, an architect and writer who specialized in technical aspects of construction, concluded after studying the wreckage that "in Boston, as in Chicago, all iron had been proved untrustworthy; cast iron, however, had stood much better than wrought iron."⁶⁶ Richard M. Hunt recommended sprinklers be installed in roofs, as was done in the factories at Lowell, Mass. Another architect suggested standpipes be installed inside buildings for fire fighting, as was done in the new store of Lord and Taylor in New York and the American Express Company building in Chicago.⁶⁷ In Boston, unlike in Chicago, none of the buildings in the burned area was fireproof. The few fireproof buildings in Boston -- City Hall, the new state house extension, the vaults on State Street and Tremont Street, the vaulted custom house -- were

⁶⁴ Quotes from Real Estate Record vol. 10 (Nov. 16, 1872).

⁶⁵ Edward Atkinson's estimate, in "The Protection of City Warehouses from Loss by Fire," Feb. 1, 1883.

⁶⁶ A.I.A., Proceedings of the Seventh Annual Convention, 1873, pp. 18-19.

⁶⁷ The Lord and Taylor store building is on Broadway at 20th Street. It was designed by James Giles and was built between 1869 and about 1872. (A History of Real Estate ... in New York, p. 616.) Peter Wight had been construction superintendent for this building.

located outside of the burned district. In fact, the new fireproof post office, which was still under construction at the time of the fire, was credited with being a barrier to the spread of the fire. Architects could learn little about the performance of fireproof buildings from this conflagration.

Structural fire protection continued to be on the agenda at A.I.A. local chapter meetings in 1873. Nathaniel H. Hutton, an architect and engineer, read a paper on fireproof construction to the Baltimore chapter, which was forwarded to the national meeting. Cincinnati members heard papers on the prevention of fires and on state building laws. The Philadelphia chapter discussed fireproof construction, the Boston fire, Mansard roofs, and the necessity of a new building code for the city. Boston's chapter meetings naturally were preoccupied with fireproofing and building law.⁶⁸ The topic continued to interest architects throughout the decade; A. J. Bloor, Robert Hatfield, Detlef Lienau, F. Schumann, and Peter Wight all read papers on fireproof construction to the A.I.A.⁶⁹

At a time when few other cities had anything besides ordinances that defined fire limits within which frame buildings were forbidden, the building codes of Boston and New York were exceptional for their comprehensiveness.⁷⁰ The amendments to Boston's building law after the fire show how a community that already accepted considerable control over building construction responded to the great fires. Boston was the seat of state government and so legislators perhaps took a more active interest in the city's welfare than, say, the rural Pennsylvania legislators in Harrisburg took in distant Philadelphia. Boston's laws relative to building construction were actually state acts (no community had home-rule in this respect).

⁶⁸ A.I.A., Proceedings of the Seventh Annual Convention, 1873.

⁶⁹ A. J. Bloor, "Report on Mansard Roofs," A.I.A. Proceedings of the Seventh Annual Convention, 1873, pp. 40-48; Robert Hatfield, "Anti-Fire Construction," AABN vol. 2 (Dec. 15, 1877), pp. 399-400; Detlef Lienau, "Fire-Proof Construction," AABN vol. 3 (Jan. 5, 1878), pp. 5-6; F. Schumann, C. E., "Fire-Proof Construction," vol. 3 (June 24, 1878), pp. 224-225 and vol. 4 (July 6, 1878), pp. 4-5; Peter Wight, "The Fire Question," vol. 3 AABN (March 2, 1878), pp. 75-76.

⁷⁰ The Committee on the Construction Buildings of the Board of Fire Underwriter in 1880 collected copies of building codes from cities around the country. It found that in many places the laws respecting building construction did no more than define the fire limits. San Francisco had a more complete code, which it modeled on New York's code. The Committee considered New York, Chicago, and Boston's codes "complete and excellent." (AABN vol. 8 (Aug. 28, 1880), pp. 104-105.)

When Boston's substantial looking, granite-faced buildings burned in 1872, everyone was surprised -- everyone, that is, but the local firemen. The granite and iron fronts of Boston's commercial structures belied what the firemen considered defective and flammable construction. Before the fire, John S. Damrell, the chief fire engineer in Boston (there was no fire commission in the city until 1874), "notified" the Board of Underwriters of Boston about "the great risks they were assuming in writing on such buildings" as if they were first-class risks.⁷¹ A result of this agitation against prevailing construction practices, and the example of the Portland conflagration a few years earlier, was an 1871 law that created a building inspection department for Boston. That its objective was fire protection is clear from its title: "An act to provide for the regulation and inspection of buildings, and the more effectual prevention of fire, and the better preservation of life and property in the City of Boston."⁷²

With the creation of an inspection department, the city at last had a more effective mechanism for enforcing its building laws -- better than in the days of Fireward enforcers. Where once firemen were to survey buildings and try to detect non-compliance, now plans were reviewed in advance; permits were required from the department before construction could begin. However, in its technical requirements, the 1871 law mainly beefed up the provisions of earlier laws rather than departing from them. For example, the law required thicker exterior walls. Heavy walls were wanted not so much for structural stability but to keep the walls standing should the interior be gutted in a blaze and to better withstand an exposure fire (a fire on the outside of the building). Falling walls were a great danger to firemen. Nevertheless, the provisions for tying the floor frame in to the walls tended to counteract what the wall provisions were intended to accomplish -- something the code writers undoubtedly did not realize at the time. (A solution to this problem became available in the 1880s, as will be discussed in the next chapter.)

The one area in which the law broke new ground, for Boston, was with respect to emergency egress. A requirement of the 1810 fire law of Charlestown, Mass. and also of New York City's law, though not part of Boston's early laws, was that every house have a

⁷¹ Charles S. Damrell, A Half Century of Boston's Building (Boston: Louis P. Hayer, 1895), p. 118.

⁷² Massachusetts laws of 1871, chapter 280, May 12, 1871.

scuttle on the roof and ladder leading to it.⁷³ Now Boston's 1871 law also required scuttles and permanent step ladders in all buildings. It went further by treating the matter of egress in two kinds of buildings where fires had frequently cause large losses of life: tenement houses and theaters. Every tenement was required to have a "proper fire-escape, or means of escape in case of fire" and the plans for buildings for "public assemblies" had to be submitted to the inspectors and approved, as to the sturdiness of the building and "that the means of ingress and egress are sufficient." However, in neither case did the law specify what constituted proper or sufficient; the inspector was responsible for determining sufficiency. Finally, with respect to "places of amusement," the law forbade the obstruction of passage ways with seats, and required that when such buildings were occupied, all doors be kept open unless the doors open outward or swing both ways, in which case they could be closed.

Some months after this law was enacted, Chicago burned down. Massachusetts lawmakers revisited their law, but apparently found little to alter. The amendments of 1872 in fact relaxed some provisions, for example, wooden buildings were permitted on wharves and for storage.⁷⁴ And then central Boston itself burned down.

The building law passed immediately after the fire introduced some new ideas. For one, fireproof shutters and doors were now required on stores over 45 feet high. With respect to egress, buildings in which many people gathered or worked -- railroad stations, halls, schools, hotels, tenements, and factories -- with more than 25 people above the first floor, had to have noncombustible stairways, enclosed behind noncombustible walls, of a width approved by the inspector of buildings, and to have outward opening doors. In addition, any buildings where "operatives" worked above the second story had to have fire-escapes, still not specified. Finally, this law, like New York's law of 1871, required that roofs on tall buildings be fireproof. New York's law required that Mansard roofs on buildings over three stories be fireproof, while Boston's law required that all roofs -- Mansard or any other -- under certain conditions had to be "constructed of fire-proof material throughout" and all

⁷³ Charlestown building law: Massachusetts Laws of 1810, chapter 44, Feb. 15, 1810. New York's law, mentioned in William J. Fryer, Jr., in History of Real Estate...in New York City, p. 288. The Boston law, chapter 171 of Massachusetts laws of 1818, did not require a scuttle.

⁷⁴ Massachusetts laws of 1872, chapter 260, April 25, 1872.

roofs on buildings over 65 feet tall had to be "constructed in a fire-proof manner." This "manner" was even defined: the law listed the kinds of materials that could be used in the frame and covering of the roof. The law made no other requirements for fireproof construction, and while it seemed to limit building height to 75 feet, this provision was not enforced.⁷⁵

In Chicago, agitation in favor of building regulation was strong after the fire, but public opinion was divided. The most the faction that urged stronger building control measures could hope for was the exclusion of wood buildings from the building limits. This was, of course, a very old and rudimentary measure, one that Boston owners had accepted for years. However, many Chicagoans objected to paying the extra construction cost it would impose. Because of opposition, the fire limits as defined shortly after the fire, within which wooden buildings were prohibited, included only a small area of the downtown. There were no requirements for fireproof construction.

Chicago was hastily rebuilt. While the downtown buildings had more substantial walls, some actually had treacherous Mansard roofs, to the consternation of members of the nascent trade association for the fire insurance industry, the National Board of Fire Underwriters. When yet another, although much less devastating, conflagration struck the city in July, 1874, the National Board had had enough. This fire burned down a district with many wooden buildings, including Chicago's beleaguered post office, which had set up temporary offices in a former church; but it was stopped at the new masonry storefronts in the business district. The National Board sent word to local agents that its members would discontinue doing business in Chicago unless the city took a number of steps, including enacting stronger building laws and providing for the enforcement of the laws. When the city did nothing, the National Board called on its members to withdraw on October 1, 1874. Only then did the city comply with the Board's conditions.⁷⁶

One might expect that the owners in Chicago and Boston, of all places, would rebuild fireproof, but this was not the case. The desire to rebuild quickly and tight capital prevailing

⁷⁵ Massachusetts laws of 1872, chapter 371, Dec. 15, 1872.

⁷⁶ Hawthorne Daniel, The Hartford of Hartford (New York: Random House, 1960), pp. 150-152.

against fireproof construction. Even fewer of Chicago's early post-fire buildings were fireproof than before the fire. As one Chicago architect explained, "an absolutely fire-proof construction ... is too expensive for general adoption."⁷⁷ Boston's post-fire buildings were more substantial and some had iron roofs. As in Chicago, perhaps a handful were fireproof.⁷⁸ A panic that began in 1873 depressed the number of buildings constructed altogether until the end of the decade.

This relative lack of fireproof construction in the decade contrasts sharply with the interest in the field of structural fire protection. A number of architects, engineers, and materials manufacturers began to study fire protection systematically. While they did not always draw the same conclusions from the great fires, these specialists agreed on two points: first, that brick held up far better in a fire than did stone, and second, that iron, while noncombustible, could not be considered fireproof. The Boston conflagration showed that building stone, especially granite, was a poor fire resisting material. Most varieties of building stones spalled, cracked, or turned to powder after being heated in a fire and then pounded with water.⁷⁹ Brick walls, on the other hand, "if well constructed, had given up their contents uninjured."⁸⁰ Noncombustibility alone could not guarantee security, and this was also true of iron.

Up till this time, architects had left iron columns and beams exposed. Indeed, some considered exposed iron beams a notable architectural feature since they expressed the mechanics of a building's structure. For example, the architect Leopold Eidlitz, in his response to a paper in which architects were faulted for avoiding iron as a building material, stated that the contrary was more true. Architects were "daily making extensive contracts for iron-work ... amounting even to 33 per cent. of the cost of structures that are erected in stone

⁷⁷ G. P. Randall, The Great Fire of Chicago and Its Causes (Chicago, 1871), p. 4.

⁷⁸ One source of information on the extent of fireproof construction in Boston in this decade is John E. Whiting, A Schedule of the Buildings...in the City of Boston. Whiting indicates that about a half dozen buildings were fire resistant; many more had fireproof boiler rooms and internal water supply for fire fighting.

⁷⁹ In tests, only sandstone -- for example, the brownstone of New York City -- was found to withstand fire and water well.

⁸⁰ R. Hatfield's observations of Boston after the fire, A.I.A. Proceedings of the Seventh Annual Convention, 1873, p. 19.

and brick" and this iron was not "used for secret construction, but avowed in broad daylight as an essential feature and preponderating element of modern construction."⁸¹ Eidlitz was convinced that constructive necessity was the source of true architectural beauty.

Unfortunately for architects who felt as he did, structural iron had to be hidden if it was to be insulated from fire.

The solution to the "fireproofing" problem, therefore, was to protect structural members with materials that were "non-conductors of heat, as well as non-combustible."⁸²

A Decade of Experimentation with New Fireproof Construction Materials: the 1870s

The 1870s was a decade of much invention and experimentation with respect to fireproof construction even though the economic depression that began in 1873, and lasted most of the decade, forestalled the implementation of new ideas to any general extent until the 1880s. Nevertheless, the ground work for advance in fireproof construction was laid in this period. The most important innovations were the products of lessons taught by the great fires. The first lesson was the superiority of brick as a fire-resisting material. Many of the new building products were made of clay. The second lesson was that iron had to be insulated from heat. This led to the development of covering for iron columns and beams.

Two styles of fireproof building evolved. One was an elaboration of the iron and brick arch building, but with hollow blocks substituting for common bricks in the floor and roof arches and partition walls. These hollow blocks were made of two materials: concrete and, more commonly, fired clay. Floors constructed with hollow blocks typically weighed less per foot than floors made of brick arches. Brick arches leveled up with concrete weighed about 70 pounds per square foot, not counting the weight of the beam, flooring or ceiling.⁸³ A lighter floor resulted in a savings in iron, and wall and foundation material, or alternatively, allowed more building to be constructed for a given foundation. The second style of fireproof

⁸¹ L. Eidlitz, "Cast Iron and Architecture," The Crayon vol. 6 (January, 1859), p. 21. Paper given at New York A.I.A. meeting December 21, 1858.

⁸² A. J. Bloor, "Report on Mansard Roofs," A.I.A. Proceedings of the Seventh Annual Convention, 1873, p. 41.

⁸³ William J. Fryer, Jr., Architectural Iron Work (New York: John Wiley & Sons, 1876), p. 91. This is roughly the figure reported by Robert G. Hatfield in "Fireproof Floors for Banks...", p. 35.

building also was a version of an earlier type, the "compartment system" building, with fire barriers under and over ordinary floors. These barriers were panels were made of clay or concrete, and iron lath and plaster. A building of the second type cost much less than an iron and hollow block building and still was practically fireproof.

Hollow Tile Fireproof Building Blocks

The important new fireproof building material of the 1870s was fired clay, called either *terra cotta* or, more commonly, *tile*. The words *terra cotta* and *tile* can be used interchangeably, but the word *terra cotta* was invariably applied to ornamental building materials made of clay while the non-ornamental, structural products made of clay were called both *terra cotta* and *tile*. To avoid confusion, the word *tile* will be used when discussing the latter type. *Tile* in this case refers to the material rather than the shape of the product, although the thin, rectangular units used to cover floors, walls, and ceilings were also called "tile." (Bricks are also made of clay, but were simply called bricks.) For the history of the introduction of structural tile in the U.S., Peter B. Wight's voluminous writing on the subject is an invaluable resource. Wight -- a tile manufacturer, architect, and fire protection authority -- did much research on the background of hollow tile in order to defend himself in a patent infringement case in the 1880s, and his articles on the history of tile include this research.⁸⁴

Hollow tile blocks had been used in England and France since the end of the eighteenth century: the arch pots, mentioned in Chapter 2, are an example. By the 1830s in England, clay structural units were being shaped by machine.⁸⁵ By this time, clay pipe was being shaped by machine, and presses like pipe presses were used to make some of the early hollow tile. Mechanical production was a necessary element in the commercial success of the product.

An early hollow tile system that gained an above average amount of exposure was one patented by the architect Henry Roberts in 1849 and used to construct model dwellings

⁸⁴ Peter Wight, The Brickbuilder vol. 6 (May, 1897), p. 98.

⁸⁵ John J. Webster, in his survey of the field of fireproof construction in Britain, mentions several patents. ("Fire-proof Construction," p. 264.)

sponsored by Prince Albert at the Great Exhibition in South Kensington.⁸⁶ In his 1854 textbook on iron construction, William Fairbairn described a hollow brick floor that he built in the Saltaire mill (1850-53).⁸⁷ A floor made of hollow blocks of a similar design was patented in 1858 by Joseph Bunnett.⁸⁸ This floor was notable in that the arch was designed to span from wall to wall of rooms rather than from girder to girder. Bunnett introduced two kinds of blocks: one with the cavity running perpendicular with the beam, and the other with the cavity running parallel. The blocks were about the size of large bricks and were made mechanically, with brick making machines. (Illustration 4-4.) Hollow tile floor systems were less commonly used in the 1860s and 1870s in England than were concrete floor systems for fireproof buildings.

By contrast, in Paris, hollow tile was the most common material for floors in residential buildings in the 1860s.⁸⁹ Since the eighteenth century, hollow tile had been used more extensively in building construction in France than in England.⁹⁰ Light, rolled joists were a widely used in building material in France, where rolled iron had long been favored over cast iron -- the material preferred by the English.⁹¹ Because the rolled joists in France

⁸⁶ S. B. Hamilton, "A Short History of the Structural Fire Protection of Buildings," National Building Studies, Special Report no. 27 (London: HMSO, 1958), p. 15. The floor arch was illustrated in Edward Dobson, "Rudimentary Treatise on the Manufacture of Bricks and Tiles," (London).

⁸⁷ On the Application of Cast and Wrought Iron to Building Purposes; construction dates, Colum Giles and Ian Goodall, Yorkshire Textile Mills, 1770-1930 (London: HMSO., 1992), p. 102; beam material and spacing, J. J. Webster, "Fire-proof Construction," p. 264.

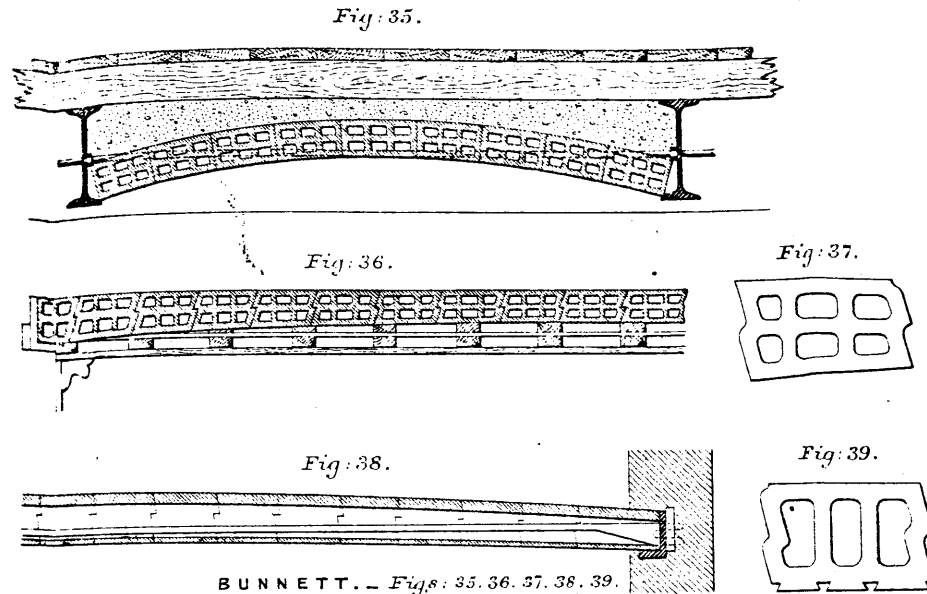
⁸⁸ Henry Eyton, Journal of the Society of Arts vol. 12 (Sept. 20, 1864), p. 722; John J. Webster, "Fire-proof Construction," p. 269.

⁸⁹ A practical mason, who reported on the construction of houses in Paris for the U.S. Commissioners to the Paris Universal Exposition in 1867, described the floors as being made of arched I-section beams, about two feet apart, filled with hollow bricks bedded in plaster. ("Report upon Building, Building Materials and Methods of Building," p. 34.)

⁹⁰ See a catalogue of such buildings in Charles Eck, Traite de Construction en Poteries et Fer (Paris: J. C. Blosse, 1836).

⁹¹ Frances Steiner, French Iron Architecture, PhD dissertation, Northwestern University, 1977. The British historian of the iron and steel industry, W. K. V. Gale, writes that because of the practical limitation on the size of a puddled iron balls, large section beams could not be rolled and therefore wrought iron was not much used for beams; joists awaited the steel age. ("The Rolling of Iron," Transactions of the Newcomen Society vol. 37 (1964-65), pp. 35-46.) But the size of a puddled ball did not limit joist size in France and the U.S., where pieces were joined by welding. The French made much use of small joists and also truss beams.

Illustration 4-4. Bunnett hollow tile floor, three styles.



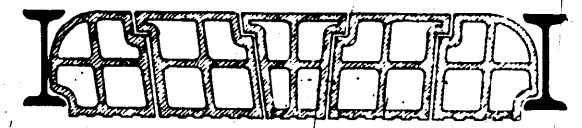
were small, the span of the hollow tile arches was short, while the span of English hollow block floor arches of the time was long -- running between walls or, in the case of the Saltaire mill, for example, between large, cast iron girders.⁹² So the French used a greater number of iron beams to construct their hollow tile floors, but the floors still were lighter than the British tile floor. French hollow tile floors also weighed less than French concrete floors. A variety of styles of hollow tile floors were available in France, including, importantly, blocks like voussoirs with angled sides and center keys, which formed flat arches.

American hollow floor systems were more influenced by the French hollow block floors than the English systems. Peter Wight believes the earliest patent for a hollow tile floor made of voussoir-shaped block was that of the Frenchman, Vincent Garcin, in October

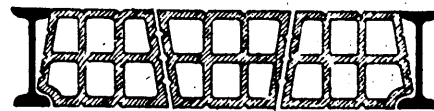
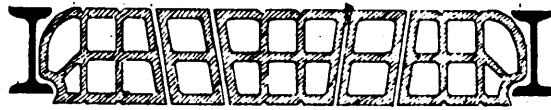
⁹² The Bunnett arch could span 21 feet and the arch in Saltaire mill was ten feet. (J. J. Webster, "Fire-proof Construction," p. 264 and p. 269.)

11, 1867.⁹³ In the next year, a circular from the Roux Brothers in France illustrated similar voussoir-shaped flat floor arches. (Illustration 4-5.) The voussoir style flat arch became the most popular type in the U.S. in the 1880s.

Illustration 4-5. Hollow tile floor blocks made by the Roux Freres, France, 1868.



From drawing attached to Roux Frères' Fr Patent Mar 25, 1868.



From Circular issued by Roux Frères. 1868.

This was not the first time someone had tried to introduce the idea of hollow clay building units in the U.S. In 1844, Ithiel Town patented a hollow brick, which he intended to be molded by machine.⁹⁴ Then in 1866, a Frenchman, Maurice Abord, patented a tile block here.⁹⁵ Abord's block was shaped like Peterson's block of the 1850s except that it had thicker walls, which would have made it less prone to cracking and warping in manufacture as well as stronger. Another feature of Abord's block was that it extended below and wrapped under the lower flange of the beam so as to form a continuous surface for a plaster ceiling. There is no evidence that either Town's or Abord's blocks were manufactured in the U.S.

The eventual commercial success of the hollow tile manufacture coincided with the development of the clay products industry. In the 1860s, terra cotta products (garden

⁹³ Peter Wight, The Brickbuilder vol. 6 (March, 1897), p. 55.

⁹⁴ Patent number 3762, Sept. 27, 1844. This was after his death.

⁹⁵ Patent number 57,450, August 21, 1866.

ornaments, statues, and so forth) were in fashion in Britain and terra cotta ornaments were used in building facades.⁹⁶ By the end of the decade, American manufacturers also began to make large clay objects. Early on, the clay block industry divided into two fields: one for exterior and ornamental work, and the other for interior, structural work. Firms that specialized in what came to be called architectural terra cotta made products for facades of buildings: the ornamental blocks for walls, decorative chimney tops, finials, and cornices. The other branch became known as the fireproof building or fireproofing industry; firms in this branch made structural blocks, for example, for constructing floors, partitions, and roofs. Not coincidentally, both industries got going in the U.S. about the same time, in the decade of the 1870s.

Since hollow tile arched floors will be unfamiliar to most readers, I would like to describe quickly them before proceeding. Hollow tile blocks were intended to replace bricks in constructing fireproof floors. The concrete that filled the top side of brick arch floors served no necessary structural purpose: it was excessive for the loads that in most cases the floors were expected to carry. Therefore, to lighten the weight, the blocks used to make the arch were hollowed out. Moreover, since clay could be molded, the blocks could be made in shapes so as to form a flat arch. While hollow blocks were also used to make curved arches, the flat arch was preferred for aesthetic reasons. The block in an arch that rests against the beam or wall and starts it is called a *skewback*. Floor arches in which the cavities run parallel with the beam are called "*side construction*" and those with the cavity running perpendicular to the beam, "*end construction*."

Beginning of the Hollow Tile Fireproof Building Industry

The pioneer firms in the manufacture of structural hollow tile blocks for constructing fireproof floors and so forth started up at about the same time, in 1873. Two of the firms began in New York City and one in Chicago, by a transplanted New Yorker. The question of which city was first mattered later in the century, when both cities claimed to have been the birth place of the skyscraper, which would not have been possible without light fireproof

⁹⁶ Margaret Floyd, "A Terra Cotta Cornerstone for Copley Square," PhD dissertation, Boston University, 1974.

floors. New York partisans, like the chronicler of real estate development in New York, William J. Fryer, Jr., wrote that New York had the first hollow tile building, while Peter Wight (actually a transplanted New Yorker) argued that Chicago had the first one. But in fact, the individuals who started the industry, whether in New York or Chicago, knew each other, were making similar products, and undoubtedly were inspired by French and British precedents.

The men who started the industry in the U.S. were George H. Johnson and Balthasar Kreischer. Some months before the Chicago fire, in 1871, these men together patented a large tile that resembled Peterson's tile.⁹⁷ Johnson (1830-1879) was an immigrant from England, where he had apprenticed in the building trades. He worked in New York from about 1852 to 1860 as a designer at Badger's Architectural Iron Works and then practiced architecture on his own for a time in New York and in several other cities after the war, principally designing cast iron buildings. At the end of the decade he lived in Buffalo, where he designed fireproof grain elevators.⁹⁸ Kreischer was a brick manufacturer in New York and made a variety of brick and tile products, including *fire-brick* (a kind of brick used to line furnaces and fire places). He too was acquainted with fireproof construction as he had supplied the fire-brick used in the New York Assay Office.⁹⁹

Johnson must have known Kreischer from his New York days, but their collaboration - if that is what it was -- was short-lived. On the same day the two men applied for a joint patent, Kreischer patented another floor tile in his name alone; it was shaped just like the one in the joint patent, but was made of three or more blocks.¹⁰⁰ There is no evidence that either of these Peterson-like tiles was ever manufactured.

⁹⁷ Patent number 112,926, March 21, 1871.

⁹⁸ A. T. Andreas, History of Chicago volume 3 (Chicago: A. T. Andreas Co., 1886), pp. 87-88. Johnson received ten patents in 1869 for items connected with grain elevators. (Annual Report of the Commissioner of Patents for the year 1869.)

⁹⁹ The company, in 1902 styled B. Kreischer and Son, New York Fire Brick, was established in 1845, according to an advertisement. By this time the works were at Kreischerville on Staten Island. Regarding the Assay Office, "Abstract of Disbursements for erection of Assay Office," Sept. 30, 1854, NA, RG 121, entry 26, Letters Received, Assay Office, box 285.

¹⁰⁰ Patent no. 112,930.

Johnson and Kreisler apparently went their separate ways. Johnson was among the architects and building tradesmen drawn to Chicago after the fire to share in the reconstruction work. He tried to sell his fireproof hollow block idea to what he might have thought would be a group of twice-shy owners, and he was not entirely alone in thinking there would be a market for such products. Joseph Bunnett of England also tried to sell his hollow tiles: a sample of his hollow tile arch floor was built on a vacant Chicago lot outside the office of one of Chicago's busiest architects.¹⁰¹ But neither man had much luck getting contracts.

Johnson received only two hollow tile commissions during the post-fire building boom. The best known, and one of the few fireproof buildings that went up in Chicago in the 1870s, was the Kendall Building (1872-73), which he designed with John M. Van Osdel (1811-1891). The floor in this building, as illustrated in a book published at the end of the century, was formed of hollow voussoirs -- skewbacks resting on beam flanges, intermediate blocks, and a key -- like the arch floors manufactured in France except that Johnson's lacked the interior walls, called *webs*, of the French models. (Illustration 4-6.) Johnson patented such a floor, a flat arch of multiple blocks, in 1872.¹⁰² The Kendall Building also had internal partitions of hollow tile, an item Johnson patented in 1871.¹⁰³ The importance of this project was appreciated at the time: "a party of gentlemen prominent in city affairs and local history" witnessed the construction of the Kendall.¹⁰⁴ Johnson's other fireproofing commissions at about this time were for the third Palmer House hotel, also a Van Osdel project and completed in 1875, and the Criminal Courts Building and Jail (James J. Egan (1839-1914), architect; completed in 1873).¹⁰⁵ Exactly who made the tiles for these

¹⁰¹ Peter Wight, The Brickbuilder vol. 6 (March, 1897), p. 54.

¹⁰² Patent 132,292, Oct. 15, 1872, with W. Freeborn.

¹⁰³ Patent no. 112,925, March 21, 1871. He had patented an impractical-looking hollow block before this, in 1869 (no. 86,929), which had flanges along the upper edge; it was intended for walls, not floors.

¹⁰⁴ Industrial Chicago (Chicago: The Goodspeed Publishing Co., 1891), p. 403.

¹⁰⁵ Henry Ericsson, Sixty Years a Builder, p. 206. A notable feature of the Palmer House, according to Ericsson, is that it had steel I beams imported from Belgium. The reason for this may be that duties were dropped on imported building materials (except for wood) during the rebuilding period. (A. T. Andreas, History of Chicago vol. 3, p. 59.) The Court House and Jail was on a block of North Dearborn Street between West

buildings and how they were manufactured is unknown, as Johnson did not have manufacturing capabilities at the time.¹⁰⁶ Despite the interest in his idea, Johnson found few customers in the west and returned to New York to try to do business there.

Illustration 4-6. Floor arches in the Kendall Building, Chicago. Blocks of the floor arches in the Montauk Block, Chicago, have webs.



FIG. 2.—Terra-cotta Arch in Kendall (Equitable) Building, Chicago.

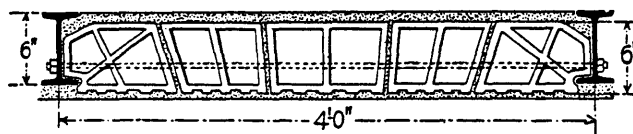


FIG. 4.—Terra-cotta Arch in Montauk Block, Chicago.

Meanwhile, the firm Heuvelman, Haven & Company (HHC) in New York had decided to manufacture hollow tile. HHC had been "agents" for and, by 1873, was the successor to Novelty Iron Works, a well-known foundry that made machinery, marine engines, and also structural iron for fireproof buildings.¹⁰⁷ In March, 1873, HHC wrote to the Supervising Architect of the Treasury Department, A. B. Mullett, to offer hollow tile blocks for use in the New York Post Office, then under construction. Although HHC's letterhead listed "hollow fire-proof tiles for floors, partitions, and vault linings" among the firm's products, HHC did

Hubbard and West Illinois Streets. Date of occupancy of the Court House from Andreas, p. 242. Date of completion of the Palmer house is given in Andreas as fall, 1873 (p. 354) and Randall as 1875 (History ... of Building Construction in Chicago, p. 54.) It may be that part of the building opened in 1873.

¹⁰⁶ Henry Ericsson conjectures that they were made at Sanford Loring's terra cotta works. (Sixty Years a Builder, p. 206.) Loring's company, Chicago Terra Cotta Company, was established in Chicago in 1868. (Sharon Darling, Decorative and Architectural Arts in Chicago 1871-1933 (Chicago: Chicago Historical Society, 1982), p. 62.)

¹⁰⁷ Letter from HHC to A. B. Mullett, March 15, 1873, NA, RG 121, entry 26, New York Post Office, 1873. Novelty's owner, the engineer, Horatio Allen, retired in 1870, which presumably is why and when the company changed hands. An ad for Novelty Iron Works in 1868 read, "they are prepared to furnish complete fire-proof structures, fronts, columns, lintels, floors, roofs, etc." (H. T. Brown, Mechanical Movements.)

not expect Mullett to be familiar with hollow tile. Hollow tile, they wrote, was "not a new thing but is used in various forms in all first class prominent Buildings in Paris and other principal Cities in Europe." They explained that HHC had commenced to manufacture hollow tile and "in a short time will have specimens to exhibit" -- which suggests that, despite what was printed on their stationery, they were just starting to produce this material. HHC also claimed that with respect to hollow tile floor arches, "the idea originated with us" although there are no relevant patents under the names Heuvelman or Haven. In fact, the company produced tiles under license from Balthasar Kreischer.¹⁰⁸ Mullett did contract with HHC for floors in the New York Post Office; their tiles were used in the halls and several rooms in the upper floors.¹⁰⁹ New York and Chicago partisans each claim the honor of being the location where hollow tile flat arches were first used in the U.S.¹¹⁰ Since construction began on the Kendall in 1872, it would seem that the honor belongs to Chicago. But the fact is, this important product was introduced almost simultaneously in both cities, and men working on the product all knew each other and drew their ideas from the same sources.

Also in 1873, the Fire-proof Building Company of New York was established by Leonard F. Beckwith, a civil engineer who had been educated in France.¹¹¹ He had been

¹⁰⁸ Peter Wight, The Brickbuilder vol. 6 (April, 1897), p. 74. In a letter to Mullett dated May 26, 1873, HHC wrote that it held patents that "cover all forms of sectional hollow tiles used in the construction of arches." NA, RG 121, entry 26, New York Post Office, 1873.

¹⁰⁹ Construction Superintendent Calvin Hulburt to A. B. Mullett, Oct. 9, 1873, NA, RG 121, entry 26, New York Post Office and Court House, 1873. The tiles were installed in the halls and the large rooms on the third and fourth stories on the Park front, and the fifth floor. There is no illustration of the tiles in the records and the building is gone; they were described in one letter as being about 6 inches wide by 12 inches long. (C. Hulburt to Mullett, Oct. 9, 1873, same collection as above.) J. K. Freitag, another authority on fireproof construction, wrote that the arches in this building, which were made by Leonard Beckwith, but this correspondence indicates that HHC was the manufacturer. (J. K. Freitag, The Fireproofing of Steel Buildings (New York: John Wiley & Sons, 1899), p. 11.)

¹¹⁰ An important chronicler of the history of fireproof construction, William F. Fryer, Jr., wrote that this was the first instance where flat hollow tile arches had been used in the U.S. or anywhere, but Parisian hollow tile arches and probably the Kendall Building pre-date the New York Post Office. (Architectural Record vol. 1 (1891-92), p. 230.)

¹¹¹ I can find out little more about Beckwith's background. Peter Wight is the source of the information about his education, "Fireproof Construction...", AABN vol 41 (Aug. 19, 1893), p. 113. In 1883, he was President of an organizing committee for U.S. exhibitors to the International Exposition in Nice. (IA vol. 2 (Aug., 1883), p. 88.)

one of the commissioners to the Paris Universal Exposition in 1867 and wrote a report on the structural concrete, called *beton-coignet*, which was exhibited there; he also visited projects where it had been used.¹¹² Beckwith was impressed with the potential for this material, which was molded both en masse (cast in place) or in blocks, and presumably the first structural blocks he manufactured were made of concrete -- a recipe that included French cement, plaster, and coal cinders -- based on French methods.

Although Beckwith apparently was the first American to use this combination of ingredients, he did not take out a U.S. patent for it, or for his manufacturing process or the design of his blocks.¹¹³ This is surprising since a recipe for concrete that would give good results was a great desideratum. A few years before this, Kreisler had patented a concrete material for making hollow blocks which was similar to Beckwith's concrete -- also made with hydraulic cement and coal ashes, but with calcined fire-clay instead of French plaster.¹¹⁴ While his 1871 patent predates the start of Beckwith's business, there is no indication that Beckwith and Kreisler clashed over these products. Whether or not Kreisler ever manufactured concrete blocks also is unknown.

The Fire-proof Building Company did not only make concrete blocks. Soon after the company got started, according to Wight, it also began to make flat floor arches of clay, under license from Johnson.¹¹⁵ However, in 1874, it had its own patent for a flat arch of clay blocks -- that of Arthur Beckwith, also a civil engineer, superintendent of the company,

¹¹² Leonard F. Beckwith, "Report on Beton-Coignet, its Fabrication and Uses," Reports of the United States Commissioners to the Paris Universal Exposition, 1867 vol. 4 (Washington: GPO, 1870). Available in the serial set, no. 1354. The inventor was Francois Coignet.

¹¹³ Peter Wight writes that Beckwith's company "control(led) certain process patents for using cement and plaster." (The Brickbuilder vol. 6 (April, 1897), p. 74.) I searched the U.S. Patent Office Official Gazettes for Leonard Beckwith patents, using the pre-1873 subject index and annual indexes by name. There were not patents for him through the mid-1870s, save for one taken out with Arthur, for a cake oven. So I can not say what patents Beckwith controlled.

¹¹⁴ Patent no. 112,929, March 21, 1871.

¹¹⁵ Peter Wight, "Fireproof Construction and the Practice of American Architects," AABN vol. 41 (Aug. 19, 1893), p. 114.

and presumably Leonard's brother.¹¹⁶ It seems that floor arches made of clay were used in parts of Beckwith's earliest buildings: the Delaware & Hudson Canal Co.'s Coal and Iron Exchange (1873-1876) and the Tribune Building (1873-1875) in New York City. The clay arches were used in rooms and corridors that were to be finished with mosaic floors. Elsewhere, presumably, the arches were concrete.¹¹⁷ Wight implied that the company had more success with clay than concrete blocks, writing that "it was not until (Beckwith) substituted burned-clay hollow blocks for the plaster blocks that he did any work that was successful and permanent."¹¹⁸

Although this comment suggests that the concrete blocks were undesirable in some way, Beckwith continued to make concrete blocks, so some customers found them satisfactory. In fact, he exhibited blocks of "Teil lime composition" at the 1876 Centennial Exhibition and received a commendation for them and an approving report by Richard M. Hunt, who designed the Coal and Iron Exchange and Tribune buildings, for which Beckwith had been the floor contractor.¹¹⁹ Fire-proof Building Company's advertisement, c. 1878, mentions its "Hydraulic Lime of Teil (France)" blocks as well as "Hollow Bricks of all kinds."¹²⁰ With the company offering both concrete and clay blocks from the start of their business, and continuing to produce both, it is difficult to know which kind were most in demand in the 1870s. It would also be interesting to know how a company reportedly established to make concrete blocks in molds could quickly find a suitable clay mine and

¹¹⁶ Patent no. 151,826 (May 9, 1874). Arthur also wrote a report for the U.S. Commissioners to the Paris Universal Exposition, 1867, on asphalt and bitumen for making streets and sidewalks. An advertisement for the company in AABN, July 12, 1884, lists Arthur as the superintendent.

¹¹⁷ That two different materials were used to make arches in the Tribune Building might explain the disagreement between sources noticed by the historian, Sarah Landau. She writes that one source -- the New York Daily Tribune itself -- described the floors as made of cement blocks, while New-York Sketch-book of 1874 described the arches as terra cotta. ("Richard Morris Hunt: Architectural Innovator and Father of a 'Distinctive' American School," in Susan Stein, editor, The Architecture of Richard Morris Hunt (Chicago: U. of Chicago Press, 1986), p. 58 and footnote 30, p. 74.) Wight wrote that "the avowed object at the time was that they (clay arches) would be better than cement (blocks) in hallways and rooms which were to be finished with encaustic tile floors." (Peter Wight, "Origin of Hollow Tile," p. 74.)

¹¹⁸ Peter Wight, "Fireproof Construction and the Practice of American Architects," p. 114.

¹¹⁹ R. M. Hunt, "The Architectural Exhibits of the International Exhibition," Reports of the U.S. Centennial Commission (Washington: GPO, 1880), p. 14 and p. 71.

¹²⁰ For example, AABN vol. 3 (Jan. 5, 1878).

presses, and make blocks in a completely different way. Unfortunately, no trade catalogue for this company has turned up, which might shed some light on the business.

While the lack of sources from the early 1870s makes it difficult to trace the progress of the three companies, it seems that none of them did a large business in their new products. Of course, no building company did a large business during the depression of this decade. Nevertheless, the blocks may have had trouble gaining acceptance because, although they had some advantages over the alternatives, they were not cheaper and their performance was unknown.¹²¹ The advantages of the hollow tile system varied with the design of the blocks, but most hollow tile floors were lighter and took up less headroom; also, flat arches formed ceilings that could be plastered directly, saving the cost of lath. Specifics on the cost of the tile floors are scarce, but some characteristics of hollow block arches in this early period suggest that they were no bargain. First, the hollow blocks were custom made. Beam spacing, anticipated floor loads, beam sections -- all of these factors would have varied and blocks would have been shaped according to the requirements of a particular building. An 1878 advertisement for Beckwith's company, for example, states the company supplied "Hollow Blocks of any pattern," which suggests not that all patterns were stocked, but that blocks were made to order. Second, hollow blocks were made with expensive materials: cement, plaster, and fire-clay. All three of the fireproofing companies from the early 1870s used fire-clay in their tile blocks.¹²²

Government records provide one example of the cost of tile compared with the cost of iron and concrete arches. For the New York Post Office, HHC contracted to supply and install tile floor arches at 40 cents per foot. This was about the same cost per foot bid for

¹²¹ The economist Marian Bowley suggests these categories for new products: cost savings or product improving. (The British Building Industry (Cambridge, England: Cambridge U. Press, 1966).

¹²² Wight writes that manufacturers outside of Chicago used "any refuse clay" in making arches. (Wight, The Brickbuilder vol. 6 (April, 1897), p. 75.) But the evidence from the time suggests that they used fire-clay. For example, in trying to persuade Mullett to use its hollow tile, HHC wrote that it had "found a superior quality of clay of which to manufacture them," suggesting that it was not indifferent to the material. (HHC to Mullett, March 15, 1873, NA, RG 121, entry 26, New York Post Office, 1873.) Beckwith's blocks in the 1870s were made with a variety of costly materials, including fire-clay. Johnson & Co.'s arches for Chicago City Hall were made of fire-clay, although the Court House arches were not. (See Wight, above, pp. 74-75.

corrugated iron arches, delivered and installed, for the same building.¹²³ Presumably the price of the iron arches did not include the concrete fill; with this added in, the iron arches would have been more expensive than the tile arches. But HHC complained that it was losing money on its tile contract, so the true cost of the tile floor must have been more than 40 cents per square foot -- perhaps equal to the full cost of iron arches filled with concrete.¹²⁴ Tile arches would have been lighter than iron arches and this could have resulted in savings in other materials, for example, in foundation material, perhaps wall material and in structural iron, if lighter beams were used. Thus, if all materials were carefully scaled to the weight of the hollow tile floors, some savings should have been realized with tile arches. Unfortunately, it is hard to know whether owners achieved these savings. Peter Wight, writing in 1879, just before demand for hollow tile increased coincident with the business recovery, described brick arch floors as "the simplest, strongest, and cheapest" kind.¹²⁵

While the high first cost tile arches was a disincentive to owners, so was the fact that Americans had no direct knowledge of how well hollow tile floors performed. How were potential customers to know whether the products would carry the required loads or even would withstand a fire? In fact, convincing customers of the effectiveness and safety of the various new products for fireproof construction was no trivial matter. Manufacturers tried to reassure customers in one of two ways: 1) testimony of authorities and satisfied customers and 2) tests. As an example of the former, Philadelphia Architectural Iron Company, manufacturer of corrugated iron arched ceilings, included customer endorsements in its 1872 advertising circular.¹²⁶ The tests manufacturers conducted might be for a potential customer

¹²³ C. Hulburd, Construction Superintendent, to A. B. Mullett, Oct. 9, 1873; bid of Philadelphia Architectural Iron Col. for no. 16 galvanized, corrugated iron arches, furnished and set in place, 40 cents per square foot (Nov. 14, 1873), and George Dwight & Co., same as above, for 46 cents per square foot (Nov. 15, 1873). NA, RG 121, entry 26, New York Post Office, 1873.

¹²⁴ William Fryer, Jr., in an 1876 handbook, calculated the cost of tile floors installed, including transportation and royalties, but excluding profit, to be 37 cents per foot. (Architectural Iron Work, p. 128.)

¹²⁵ AABN vol. 5 (May 31, 1879), p. 172.

¹²⁶ Philadelphia Architectural Iron Company, Philadelphia, 1872; trade catalogue in the collection of the National Museum of American History.

for presumably objective authorities -- architects, engineers, and prominent businessmen. HHC installed a sample of its tile in the New York Post Office and also conducted a test for the government, which they said proved the "strength and practicability" of the product.¹²⁷ The Fire-proof Building Company states in its advertisements that "our Fire-Proof work is the only one approved by the New York Board of Fire Underwriters and the Superintendent of Buildings after severe public tests."¹²⁸ In its first trade catalogue, New York Terra Cotta Lumber published results of tests made by the Riehle Brothers and experiments by a consulting engineer, and wrote that results of more tests would soon be available.¹²⁹

While such tests may have satisfied some customers, they could not be conclusive. These individual tests were idiosyncratic. One architect who was familiar with the testing work of the Treasury Department's Construction Office in the 1850s lamented that the government no longer provided this service. How, he asked, were architects to know the relative merits of new products since they did not have the means to test products comparatively for themselves and manufacturers did not divulge complete information?¹³⁰

Given the uncertainty, it is interesting to note that the Fire-Proof Building Company seems to have been the most successful of the three hollow tile companies in this experimental period, and the reason for this, Wight suggests, was that architects trusted Beckwith himself. Beckwith's blocks "received great favor from architects at the seaboard cities, mainly on account of the confidence reposed in (Beckwith's) scientific attainments."¹³¹

He was the first practical expert in fire-proofing in America who put his inventions into extensive use. ... Mr. Beckwith made his own specifications, which were acceptable to the Eastern architects, and carried out his own contracts.¹³²

¹²⁷ HHC to A. B. Mullett, May 26, 1873, NA, RG 121, entry 26, New York Post Office, 1873.

¹²⁸ AABN vol 3 (Jan. 5, 1878),

¹²⁹ Terra Cotta Lumber, New York, 1882, collection of the Library Company, 1882, pp. 29-33.

¹³⁰ "Civis," "The Office of the Supervising Architect; What it was, what it is, and what it ought to be," New York, 1869, in the collection of the A.I.A. archives.

¹³¹ Peter Wight, "Origin and History of Hollow Tile Fire-Proof Floor Construction," The Brickbuilder vol. 6 (April, 1897), p. 74.

¹³² Peter Wight, "Fireproof Construction," AABN vol. 41 (Aug. 19, 1893), p. 14.

Among Beckwith's projects in the early 1870s were: the Bennett and Drexel Buildings (both by Arthur Gilman and begun 1872); Western Union (George B. Post, begun 1872); Delaware & Hudson Canal Co. Coal and Iron Exchange Building, Tribune Building, and Lenox Library (begun 1871), in New York City, all designed by Richard M. Hunt. These buildings were outstanding technological achievements of their day. The Western Union and the Tribune buildings, because of their unprecedented heights, were considered New York's first skyscrapers. The Delaware & Hudson Canal Co. building was praised in an 1876 speech by the President of the National Board of Fire Underwriters as an exemplary fireproof building.¹³³ Projects outside of New York included the Peabody Institute and Baltimore Safe Deposit Co. in Baltimore, Peabody Museum in New Haven, and Syracuse Savings Bank.¹³⁴

Although they may not have been adopted at the time, there were many patents in the 1870s aimed at improving the shape of floor blocks and the material for making hollow blocks. At the end of 1872, a flat arch floor system, made of deep hollow blocks, each one having a central web like the French blocks, was patented by Wear L. Drake of Evanston, Illinois.¹³⁵ Another notable feature of this arch is that it had projections off from the outer corners of the skewback tile that wrapped over the top and under the bottom of the beam to insulate it, showing that already at this early date some people understood the need to protect iron beams. Another idea introduced at this time was for an "end construction" style of arch. Arthur Beckwith's 1874 arch was perhaps the first American example of this type (one of Bunnett's arch designs was also an "end construction" style of flat arch). Wight believed that the architect Levi Scofield's patent was the earliest American example of an end construction arch.¹³⁶ But Beckwith's design, with voussoir shaped blocks, was more like the end construction arches that came to be used commonly in the last decade of the century,

¹³³ Henry Oakley, "Address," Decennial Meeting, N.B.F.U. of the U.S., April 26, 1876.

¹³⁴ Projects listed in Fire-proof Building Co. advertisement, AABN vol. 3 (Jan. 5, 1878).

¹³⁵ Patent no. 140,352, Dec. 3, 1872.

¹³⁶ The Brickbuilder vol. 6 (May, 1897), p. 99. Patent no. 161,357 (Dec. 12, 1874). Scofield patented another fireproof floor made of tiles shaped like curved I beams, which rested on the lower flanges of iron I beams. (Patent no. 161,356, March 6, 1875.)

although it is not clear that Beckwith's patent was a model for the later versions of this idea. Scofield's blocks, in contrast, were large, one piece tiles, and had the drawbacks of Frederick Peterson's Cooper Institute tile, introduced twenty years before.

George Johnson patented an idea for a floor that was both simpler to manufacture and did not have to be custom made; it was made of fire-clay tubes alternating with concave "binders."¹³⁷ The tube in this floor could have been made on a sewer pipe press. A small sample of this floor was tested by the engineers of the new Capitol building in Albany, New York, in 1874, then in the course of construction, at the building site. The sample (covering an area four feet across and one foot wide) held up well under a heavy load.¹³⁸ Despite this successful test, the floor does not look sturdy; it is neither a lintel or an arch, but seems to rely on the adhesive power of the mortar to remain in place. (Illustration 4-7.) Nevertheless, it is an example of a simpler type of system, made of only four block shapes (two skewback, a binder, and a tube). Developing hollow tile floors along the lines of easy to make shapes and a minimum number of block shapes in each arch, was the direction of invention. In 1879, Leonard Beckwith patented a floor system that also consisted of only two blocks, of fairly simple shape.¹³⁹ The arch was formed of a small, angled block that served as a skewback and a long block, with cavities running perpendicular to the beam (as in end construction). Although these blocks had the advantage of being easier to produce than other, more elaborate hollow voussoir blocks that were being made in the early 1880s, Wight does not recall having ever seen "these arches put into practical use."¹⁴⁰ Since the potential span of this arch was not long, it would have required more iron than other styles of floor arches.

Inventors sought other uses of hollow blocks, besides for floors and partitions. One great stumbling block for fireproof construction had been the roof. The roofs of solid masonry buildings typically were made of wood, which compromised the fire resistance of the structure. The roofs made of iron frames covered with corrugated iron plates, such as those

¹³⁷ Patent no. 143,351, July 14, 1874.

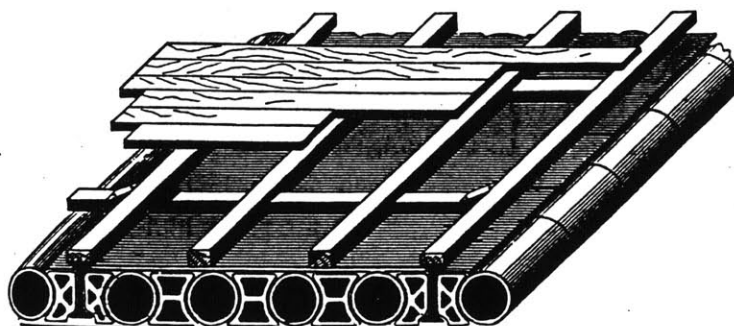
¹³⁸ William Fryer, Jr., Architectural Iron Work, p. 129.

¹³⁹ Patent no. 221,501, filed Oct. 3, 1879.

¹⁴⁰ The Brickbuilder vol. 6 (May 1897), p. 99.

Illustration 4-7. Floor of tile tubes and binders.

FIRE-PROOF CYLINDRICAL TILE FLOORS AND CEILINGS.



on the federal buildings of the 1850s, invariably leaked. An innovation in the 1870s was to use hollow tile as a roof cover. One early patent for using tile in this way was taken out in 1873 by George Johnson and William Fryer, Jr. Their block was a hollow, rectangular clay slab, rabbeted on two sides in order to inter-lock; the patent listed a variety of materials for making the blocks, including clay.¹⁴¹ Perhaps the first use of tile blocks to make a roof was in the Chicago Water Works, which was fitting since it was the collapse of the roof the old water works that destroyed the city's pumping engines and incapacitated the fire fighting effort during the 1871 conflagration.¹⁴² The tiles forming the roof of the new water works buildings were large blocks made of "porous terra cotta" laid on a framework of T iron.¹⁴³ In finishing such a roof, the blocks would be covered with slate, metal sheets, or cement composition, and, in the best practice, the flange of the T iron was also covered with tile and then plastered.¹⁴⁴

The Chicago water works roof block was an early application of porous terra cotta, a

¹⁴¹ Patent no. 143,352, Aug. 12, 1873.

¹⁴² E. Colbert and E. Chamberlin, Chicago and the Great Conflagration, p. 218.

¹⁴³ Peter Wight, The Brickbuilder vol. 6 (April, 1897), p. 75.

¹⁴⁴ Peter Wight, AABN vol. 5 (May 31, 1879), p. 172.

very important invention patented by Sanford E. Loring in 1874.¹⁴⁵ Loring's invention consisted of clay mixed with sawdust or other vegetable matter which burned out in the firing.¹⁴⁶ Loring was an architect and partner of William Le Baron Jenney,¹⁴⁷ in 1868, he became treasurer of the newly established Chicago Terra Cotta Company, and he soon gave up architectural design to work in terra cotta manufacture. The company initially made garden urns and ornaments, and then decorative terra cotta items for buildings, such as door and window caps, brackets, and quoins, according to an 1869 advertisement. Unlike other companies that entered the in architectural terra cotta business, Loring's also made structural hollow tile.¹⁴⁸ It was for structural tile that his porous material was intended. Porous tile was lighter than solid tile of the same dimensions; conducted heat less well and so could be used in solid form as an insulating material; and was less likely to warp or break in firing. Various recipes for porous terra cotta were developed over time, to improve their toughness.

Another early application of porous terra cotta was in column fireproofing blocks. Cast iron columns, the usual type, had long been considered unreliable in a fire. Again and again, people wrote that in a fire, cast iron columns lost strength, expanded, and snapped after being heated and doused with cold water.¹⁴⁹ Already in 1860, the New York iron manufacture J. B. Cornell patented a "double cylinder" or "fire-proof" column, consisting of two cast iron columns, one inside the other with the space between them filled with plaster.¹⁵⁰ The inner column was sized to be sufficient to carry the load unaided; the outer

¹⁴⁵ Patent no. 156,361, Oct. 27, 1874.

¹⁴⁶ AABN vol. 1 (Dec. 30, 1876), p. 421.

¹⁴⁷ I have been able to learn practically nothing about Loring's life, even the dates of his birth and death. His only published work, that I can locate, was a book of building plans, made with Jenney. (Principles and Practice of Architecture, Chicago, 1869.) Sharon Darling, in her Chicago Ceramics and Glass, an Illustrated History from 1871 to 1933 (Chicago: Chicago Historical Society, 1979), gives some information about Loring's terra cotta business, but does not cite the sources of her information. The Chicago Historical Society was not able to provide any information about the man, although it had some information about his wife, Stella Dyer Loring, who was a prominent educator in Chicago.

¹⁴⁸ For information on the architectural terra cotta business in Chicago, see Sharon Darling, Decorative Arts in Chicago 1871-1933 (Chicago: Chicago Historical Society, 1982).

¹⁴⁹ For example, Peter Wight in AABN vol. 1 (Jan. 22, 1876), pp. 30-31. Cast iron columns had a reputation for unreliability far beyond anything they deserved.

¹⁵⁰ Patent no. 27,528, March 20, 1860.

column was only supposed to protect the inner columns. This expensive and impractical design was required by the building code of New York City for certain situations and, being the only available fireproof column, was recommended by some authorities.¹⁵¹ In 1874, Peter Wight and his architectural partner William Drake patented a fireproof column made of a cruciform shaped cast iron core, with wood wedges fixed in between the flanges.¹⁵² This idea was never implemented in wood as Loring's porous terra cotta became available at that time and curved, foot-long plates of porous terra cotta were used instead.¹⁵³ The first building to use Wight's fireproofed columns was the Chicago Club House, designed by Treat and Foltz and completed 1876.¹⁵⁴ The tile wedges covering the columns were held in place by wrought iron plates that were sunk into the corners of the tiles and screwed into the column flanges; the columns were then plastered and topped with ornamental terra cotta capitals.¹⁵⁵ The Club House was not a thoroughly fireproof building, but the owners elected to take the precaution at least of protecting the iron columns. This building was a replacement for one constructed after the 1871 fire, which had the bad luck to be in the path of Chicago's next big fire, in 1874.

Cast iron columns of cruciform section were not as strong, for a given amount of material, as round, hollow columns, but attaching wedges to round columns was a tricky proposition. Wight came up with the idea of having small flanges, about 1 1/2 inches, cast on to the sides of round columns; the flanges were used to hold tile wedges. Columns of this type began to be used in about 1879. Flanges were a feature of Phoenix Iron Company's

¹⁵¹ New York's 1871 building law required that in cases where an iron column supported a wall, except in a wall fronting a street, the column had to be double, with the inner column capable of sustaining the load unaided. ("Extracts From the Building Law, of the City of New York," April 20, 1871, in William Fryer, Jr., Architectural Iron Work, p. 158.) Nathaniel H. Hutton wrote that when iron columns were needed, they should be this kind of columns: double with the space between filled with plaster or cement. ("Fire-proof Construction," Scientific American Supplement no. 10 (March 4, 1876), p. 158.)

¹⁵² Patent no. 154,852, Aug. 10, 1874.

¹⁵³ Peter Wight, "Recent Fireproof Building in Chicago, Part VI, vol. 19 (July, 1892), p. 71.

¹⁵⁴ AABN vol. 3 (March 23, 1878), pp. 102-103; AABN vol. 1 (Aug. 19, 1876), p. 271. Chicago Terra Cotta works also supplied the terra cotta for the colorful exterior of building, which included molded tiles and enamelled brick.

¹⁵⁵ Peter Wight, The Brickbuilder vol. 6 (August, 1897), p. 173.

rolled iron columns and tile wedges were made to fit these columns, too. Wight fireproofed columns in a half dozen Chicago buildings and buildings in several other cities in the mid-West as well as the U.S. Patent Office, in the first half of the 1880s.¹⁵⁶

Another of Wight's column fireproofing ideas, devised to meet requirements of the federal government for its buildings, was a system of tile rings to protect round columns. The tile plates, 1 1/2 inches thick, wrapped around the column and were held in place with iron band that fit in a grooves along the upper and lower edges of the blocks.¹⁵⁷ (Illustration 4-8.) This system was used in eighteen federal buildings in western states between 1880 and 1886.¹⁵⁸ Other manufacturers introduced other tile fireproofing systems for columns, which were less expensive, although less secure, than Wight's systems. At the end of the 1870s, these systems of column fireproofing were approved by the building department in New York as an alternative to the double column.¹⁵⁹

Interior columns were treated as architectural features and a variety of finishes were applied to them. The terra cotta formed a good surface for plaster. Keene's cement, which formed a very hard finish, was also popular. Keene's cement could be molded to form fluted shafts and bases. Capitals were most commonly made of plaster and cast iron.¹⁶⁰

Another application of porous terra cotta material was to shape it like boards, a product called "terra cotta lumber." Charles C. Gilman of Iowa patented this idea in 1881; the material described in his patent combined kaolin clay and sawdust, which burned out in the firing.¹⁶¹ This fine-grained material, unlike hard or even most porous terra cotta, could be sawed, carved, bored, and nailed. It was a good insulator and could be used as a

¹⁵⁶ Peter Wight, "Recent Fireproof Building in Chicago, Part VI, vol. 19 (July, 1892), p. 72.

¹⁵⁷ 1874 patent no. 154,852, and 1878 patent no.s 203,972 and 204,867.

¹⁵⁸ Peter Wight, "Recent Fireproof Building in Chicago, Part VI," IA vol. 19 (June, 1892), p. 72.

¹⁵⁹ AABN vol.5 (May 31, 1979), p. 172. Peter Wight reported that if the double columns, with plaster filling, were used in buildings that were unheated in winter, the plaster was liable to freeze and break the outer shell, so the columns were made leaving out the plaster. (IA vol. 19 (July, 1892), p. 71.) John Cornell patented a double column -- just a decorative iron shell around a column -- in 1868, so perhaps the plaster filling was going out of use by then. (Patent no. 74,312, Feb. 11, 1868.)

¹⁶⁰ Peter Wight, "Recent Fireproof Building in Chicago, Part VI, vol. 19 (July, 1892), p. 72.

¹⁶¹ Patent no. 248,094, Oct. 1, 1881. Mentioned in IA vol. 4 (Sept., 1884), p. 27.

Illustration 4-8. Tile column fireproofing.

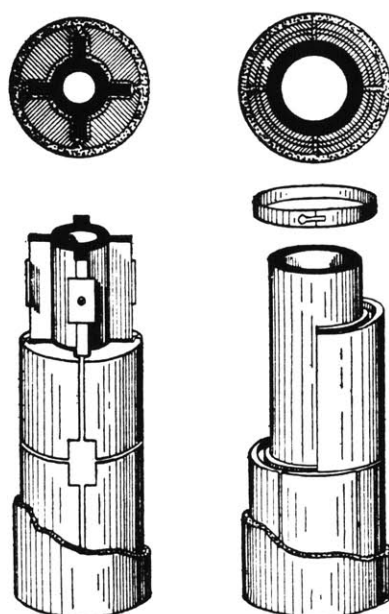


FIG. 13.—Early Forms of Column Fireproofing.

fireproofing material, or simply in place of lumber. The New York Terra Cotta Lumber Company, established 1882, bought Gilman's patents and began to manufacture terra cotta lumber in Perth Amboy, New Jersey; Gilman was President of the company. It soon offered shop rights and territory for sale. Its blocks were used for floor joists, partition blocks, roof sheathing, and column fireproofing.¹⁶²

The circle of inventors, manufacturers, and architects involved in fireproof construction at this time was not large. The connections among these men show up in the patent records. As already noted, Beckwith, Johnson, and Kreischer had business dealings with each other. Johnson also had dealings with William Fryer, Jr.; he assigned one half of his pipe floor patent to him. Fryer was the manager of an architectural iron works and became a leading figure in the development and administration of New York City's building codes and an authority on fireproof construction. The connections also show up in the lists of investors and directors of fireproof products companies. For example, among the directors of

¹⁶² In 1885, Gilman filed for patents for a variety of applications for his terra cotta lumber: patents no. 338,509 - 338,518.

the New York Terra Cotta Lumber Company were Jose de Navarro, a cement manufacturer who developed the huge, fireproof apartment complex in New York known as "Spanish Flats." Terra cotta lumber was used in this project. Another director was Adolphus Bonzano, chief engineer with the Phoenix Bridge Company, which made bridges with iron from Phoenix Iron Company.¹⁶³ Phoenix Iron, of course, made structural iron; it advertised in AABN that it made "rolled beams; roof trusses, girders, and joists for fire-proof buildings framed and fitted as per plans," in addition to its well-known wrought iron columns.¹⁶⁴

Hollow tile "slow-burning" or "partially fireproof" construction

Another reason why hollow tile was not widely adopted was that an alternative, much less expensive, system of fire-resisting construction was introduced in this decade. This was an extension of the "compartment system" approach using the new materials of the decade -- clay, concrete, and metal lath and plaster -- to make fireproof barriers in ordinary buildings. In the 1870s, when fire protection authorities began to redefine fireproof construction as a system in which structural materials were protected from heat, rather than one in which noncombustible materials were used exclusively, such buildings were sometimes called "fireproof." The logic of calling these buildings fireproof was that, since both iron and wood were vulnerable in a fire and had to be protected, then buildings in which the wood structural materials were thoroughly encased with noncombustible material should be as fire resisting as iron and tile buildings.¹⁶⁵

However, these buildings were more commonly referred to in terms that acknowledge the distinction between them and fireproof buildings. They were called "semi-fireproof," "partially fireproof," second class fireproof, and in some cases, as "slow-burning." The barrier system was very popular in the 1870s and 1880s, since it was cheap compared with first class (noncombustible) fireproof construction. Also, since the materials of construction used in these buildings were traditional ones, there were no questions about how they would perform. In this decade, through the mid-1880s, owners who wanted a fire-resisting building

¹⁶³ Names from Terra Cotta Lumber, New York, 1882; trade catalogue in the collection of The Library Company of Philadelphia.

¹⁶⁴ AABN advertisements, 1880 - 1884.

¹⁶⁵ Peter Wight, AABN vol. 5 (May 31, 1879), p. 171 and (June 7, 1879), p. 179.

were more like to chose one or another version of the barrier system than to build it thoroughly fireproof.

One type of barrier system that was used to a large extent in Chicago in this period was a form of metal lath and concrete or plaster. This system was a variation on an old idea. Indeed, James John, a Chicago builder who developed a large business installing this particular product, found that one of the inventions he tried to patent conflicted with an English patent of 1797.¹⁶⁶ In the U.S., an early form of metal lath came in dove-tailed sheets of rolled iron; plaster would have rested on the surface of the sheet.¹⁶⁷ A better version of this idea was lath made of wire, called wire cloth, or expanded metal, which was made by slitting iron sheets and then pulling each side of the sheet outward to create a metal mesh.¹⁶⁸ (Illustration 4-9.) These were improvements over the sheet metal lath because they allowed the concrete or plaster wall material to press through the mesh and encase it and thereby protect it.

James John's main fireproofing product was galvanized wire and concrete that covered wood wall studs and ceilings, a system he began installing in about 1874.¹⁶⁹ Although he did not patent this product, he did patent an idea for filling the spaces between wood joists with hollow plaster blocks and plaster, in order to make a light but airtight floor.¹⁷⁰ The wire lath and concrete method continued to be used in new office buildings in Chicago through the mid-1880s, for example in the Continental Building (George H. Edbrooke) and the Cooper & Carson Building, both under construction in 1884. It was still used in 1895 for column protection in the Seigel-Cooper Building in New York.¹⁷¹ But given the poor performance of plaster products in several fires, for example the new United Bank Building

¹⁶⁶ IA vol. 13 (Feb., 1889), p. 17.

¹⁶⁷ Illustrated in ARABJ vol. 2 (May, 1870), p. 640.

¹⁶⁸ Wire net had been used in England before the 1840s, in the Pantehnicon; a style of wire net was patented in 1841. (J. J. Webster, "Fire-proof Construction," p. 274.) Expanded metal was a U.S. product. One large manufacturer of this product was Clinton Wire Cloth company of Clinton, Mass.

¹⁶⁹ IA vol. 3 (July, 1884), p. 84.

¹⁷⁰ Patent no. 145,211, Dec. 2, 1873.

¹⁷¹ IA vol. 3 (July, 1884), p. 84; IA vol. 4 (Sept., 1884), p. 26; "Burnt Clay Fireproofing and Its Substitutes," Architectural Record vol. 8 (July-Sept., 1898), p. 112.

Illustration 4-9. 1882 advertisement for "Clinton" wire lath.

"CLINTON" FIRE-PROOF WIRE LATH

FOR

MILLS, WAREHOUSES, STORES, RESIDENCES, PUBLIC BUILDINGS, PICKER ROOMS, &c.

"CLINTON" FIRE-PROOF WIRE LATH
Is Indorsed by the Leading Insurance Companies.

It is positively FIRE PROOF,

GAS AND FLAME PROOF,

RAT AND RUST PROOF.

"CLINTON"

Wire Lath forms

a continuous and unbroken surface, thoroughly interwoven, on which to plaster, differing from Tile, Brick, and all other work constructed in sections, which in seasoning is liable to form cracks, through which the hot gases may pass.

SPACE. It occupies less than $\frac{1}{8}$ in thickness, and yet it is stronger than any other known construction.

For Fire-proof Roofs,

For Fire-proof Beams,

For Fire-proof Partitions,

For Fire-proof Picker Rooms,

For Fire-proof Walls,

For Fire-proof Storehouses,

For Fire-proof Ceilings,

For Fire-proof Varnish Rooms,

For Fire-proof Floors,

For Rat-proof Buildings,

Write for information and Circular.

Every description of Wire Cloth, Netting, Fencing, Window Guards, &c., in Iron, Brass, Copper, Steel, Tin and Galvanized Wire.

**WIRE NETTING, FOR WOOL, GLUE, AND OTHER DRIERS,
A SPECIALTY.**

NEW YORK, 68 Beekman St.
CHICAGO, 148 Lake St.

CLINTON WIRE CLOTH CO.,
CLINTON, MASS.

(c. 1880) in New York in 1883, wire lath and plaster began to be used less for fireproofing. Although it was less commonly used for structural fire protection, wire lath and wire cloth continued to be substituted for wood lath for making a surface for plastering in fire-resisting buildings.

The recommended material for constructing fireproof barriers was tile panels. The

panels in the 1870s were thin, perhaps an inch and a half or two inches deep, but hollow.¹⁷² (Illustration 4-10.) In the next decade, terra cotta lumber, produced in solid sheets, began to be used in the same way. A number of patents for fireproofing tiles were granted in this decade.¹⁷³ George Johnson, with Edwin Hall, patented a tile to protect wood floors in 1872. The system consisted of a hollow, flat block that slid over wood strips along the bottom of joists and completely filled the space.¹⁷⁴ This was conceived as a system that could be installed in existing houses in order to make them more fire-resisting. The next year, Lucien Tartiere patented a similar system, in which hollow blocks with angled slides were held in place with triangular shaped hangers.¹⁷⁵ In this case, the tile was under the joist and would have provided more protection than would the in-fill tile in Johnson's earlier patent. Henry Maurer, of Maurer & Son, a New York area brick manufacturer, patented a tile block that was similar to Johnson's, but had internal webs. He proposed blocks be placed both under and on top of floor joists.¹⁷⁶ Peter Wight patented a ceiling tile which was held in place only in the corners, rather than along its length, which he claimed made it possible to remove a single tile without disturbing the rest.¹⁷⁷ When tiles covered only the under side of joists, a double floor often was built on top, with a layer of mortar sandwiched between the boards. These tiles are unlike simple ceiling coverings, such as the contemporary tin plate, since, in order to be an effective fire barrier, they had to form an air-tight surface and be very sturdy -- capable of staying in place when water at high pressure was thrown on them from below.

Interior partitions in the compartment buildings could be made in several ways. A simple system was to build a regular stud wall, but fill the wall cavities with brick or finish the wall with metal lath and plaster, as in James John's method. Of course, hollow tile blocks could be used, but these were more expensive. Rather than furring the inner surface

¹⁷² AABN vol. 5 (June 7, 1879), p. 179.

¹⁷³ For example, 129,827, Isaac Hodson and William Brown and 133,448 Johnson and E. R. Hall, in 1872; 143,197, L. A. Tartierre in 1873; 156,808, Henry Maurer in 1874; and so on.

¹⁷⁴ Patent no. 133,448, Nov. 26, 1872.

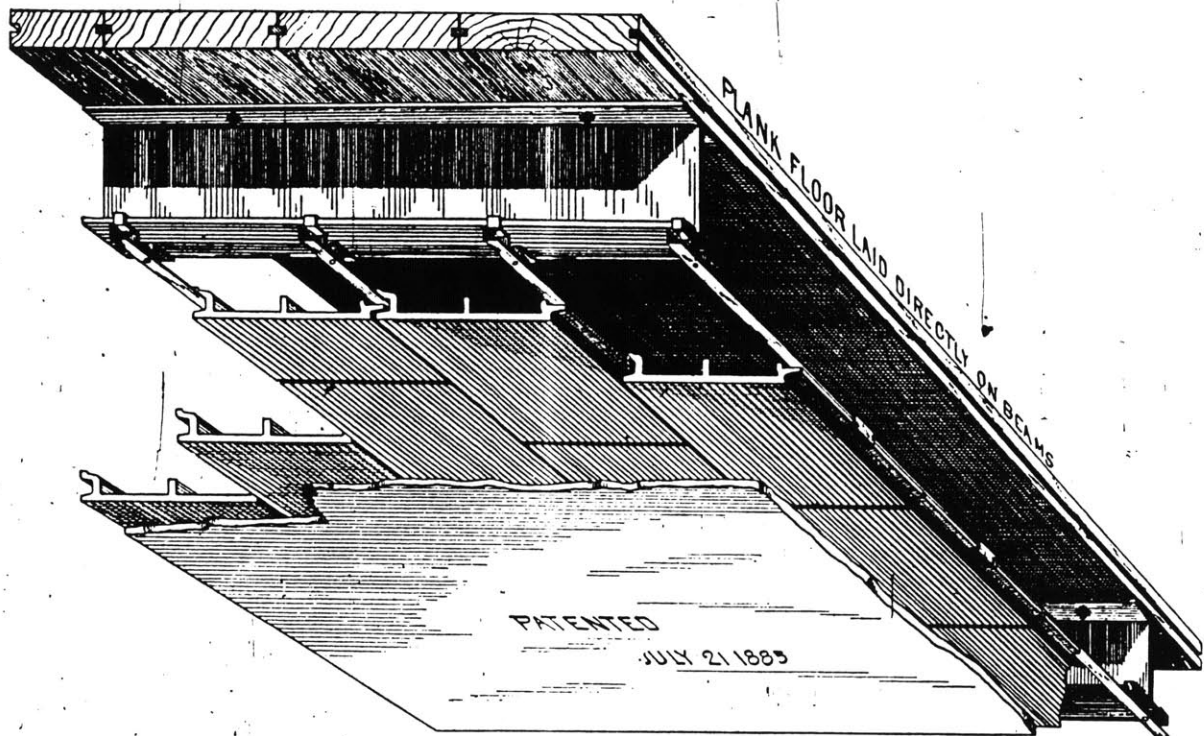
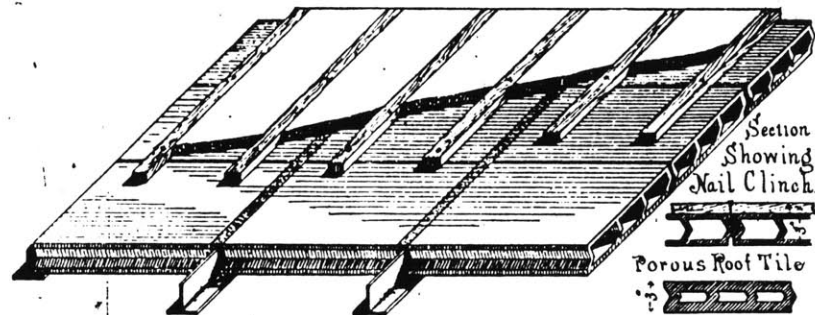
¹⁷⁵ Patent no. 143,196 and 143,197, Sept. 23, 1873.

¹⁷⁶ Patent no. 156,808, Oct. 21, 1874.

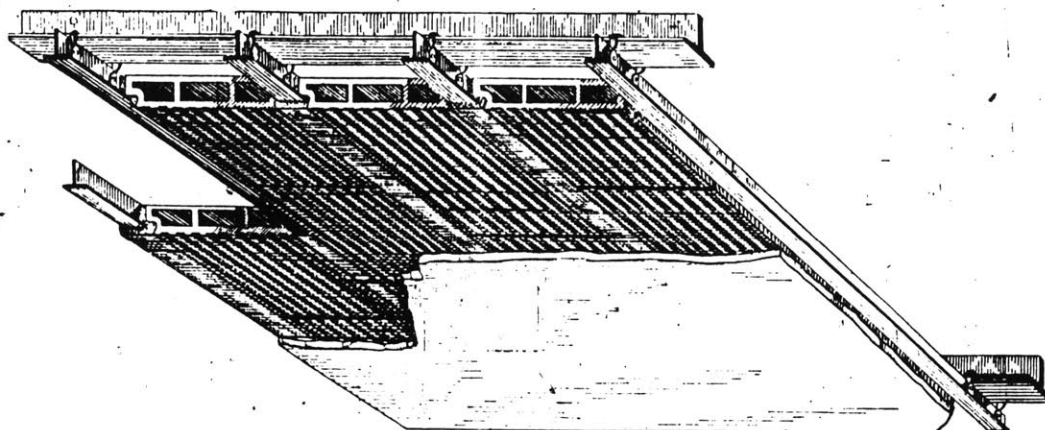
¹⁷⁷ Patent no. 202,617, Dec. 21, 1877.

Illustration 4-10. System for fireproofing wood floors and for constructing a fireproof roof.

HOLLOW TILE ROOF
With Iron T's, 3inch Locked Tiles, Wood Strips & Concrete.



Tile Ceiling Attached to Angle-Iron under Iron Beams



3inch Hollow Tile Ceiling Attached to L Beams
for Attic or Suspended Ceilings

of exterior walls with wood lath, tile sometimes used. Since wood trim could undo all the measures take to protect a building, it was used sparingly.

More of the new style fireproof buildings were in New York than anywhere else, as indicated by the many projects of the Fire-proof Construction Company in that city. In Chicago, the brick arch seems to have been abandoned. Although only about a half dozen fireproof buildings were constructed there in the 1870s, all used the new fireproofing systems. Hollow tile floor arches were used in the Kendall Building, Palmer House, and Criminal Court Building, all previously mentioned, and also in Chicago City Hall and County Court House, built slowly between about 1877 and 1885. The early projects were the work of George Johnson and the latter, of the company formed after his death by his former partner and his son, Ottawa Tile Co.¹⁷⁸ The columns in City Hall were fireproofed with Wight's system.¹⁷⁹ The Nixon Building, almost complete at the time of the fire and one of the few structures in the burned district to survive, and the new Chicago post office had floors made of corrugated iron arches filled with concrete.¹⁸⁰ Perhaps the only other fireproof building constructed in Chicago in this decade was built by the Singer Manufacturing Co., to replace its building that burned in a fire in 1877. This company had built a number of fireproof buildings, beginning with its Mott St. building in New York City (mentioned in Chapter 3).¹⁸¹

Outside of New York and Chicago, brick arches continued to be the most widely used method for buildings floors in the 1870s. For example, in Boston, the "completely fire-proof" Museum of Fine Arts, designed by John Sturgis and Charles Brigham in 1870 (although not built until five years later) followed the established fireproof system: "the partition walls are

¹⁷⁸ Buildings fireproofed by the Pioneer Fireproof Construction Company, successor to Ottawa Tile Company, were listed in an advertisement in IA July, 1885.

¹⁷⁹ AABN vol. 3 (Feb. 2, 1878), p. 43.

¹⁸⁰ On the post office, AABN vol. 56 (June 5, 1897), p. 73; on the Nixon, Henry Ericsson, Sixty Years a Builder, p. 206. The foundation of the post office (1873-1880) did not conform the special requirements for Chicago buildings, and the walls of the building cracked. It was replaced in 1905. (Frank Randall, History of Chicago Building, p. 46; A. T. Andreas, History of Chicago, p. 554.)

¹⁸¹ AABN vol. 3 (Feb. 16, 1878), pp. 58-59. It was occupied by Field and Leiter and later by Marshall Field and Co., and was known as the Marshall Field and Co. store. (Frank Randall, History of Chicago Building, p. 50.)

of brick throughout, plastered directly upon the masonry, and the ceilings and floors are of iron and brick or concrete...."¹⁸² Philadelphia's fireproof buildings from this period, such as the monumental City Hall (begun c. 1872), Pennsylvania Academy of Fine Arts (1872-76), and Ridgway Library, built for The Library Company (1873-78), had traditional brick arches with exposed beam flanges. In Rochester, New York, the floors of "Powers' Commercial Fire-Proof Building" were built of rolled iron with brick arches.¹⁸³

Nevertheless, the new systems were spreading to other cities as well. In St. Louis, the Singer Building, constructed c. 1878, was among the early buildings with hollow tile floor arches and partitions.¹⁸⁴ In Springfield, Illinois, the upper floors of the State Capitol building, constructed in the early 1870s, had blocks made of plaster and cinders designed by the architect of the building, A. H. Piequenard.¹⁸⁵ Another fireproof building in St. Louis, also constructed about this time, was the Southern Hotel (George I. Barnett, constructed 1879-1881), which was built after the destruction of the first one in an 1877 fire. It was unusual in having floors made of "railroad iron" and "cement." Whether the cement was in the form of a slab, which would have made the floors one of the earliest examples of reinforced concrete floors in the U.S. or in blocks, as they were described in a contemporary description, is unclear.¹⁸⁶ The interior partitions were either brick walls or were made of "gypsum, sand, cement, and pulverized coke." Its owner was so convinced of its "infallibility that he will not insure the house for a dollar," and he was not the first owner of a fireproof building to forego

¹⁸² AABN vol. 8 (Oct. 30, 1880), p. 206. The advertisement for designs for the building, dated June 15, 1870, stated that the "walls must be of stone, brick or iron, and the whole including the roof must be completely fireproof." ("A.I.A. Scrapbook, 1858-1874," A.I.A. Archives.)

¹⁸³ Described in Asher & Adams, Pictorial Album of American Industry 1876 (New York: Rutledge Books, 1976), reprint of 1876, p. 85.

¹⁸⁴ Peter Wight, The Brickbuilder vol. 6 (April, 1897), p. 74; IA vol. 5, extra no. (April, 1885), p. 46.

¹⁸⁵ Peter Wight, The Brickbuilder vol. 6 (April, 1897), p. 74.

¹⁸⁶ The interior is described in Commercial and Architectural St. Louis (Jones & Orear, 1888) as being constructed of "wrought iron with fire-proof blocks between." But a brochure about the hotel describes the floors, meaning no doubt the floor boards, as "laid on solid cement." (The New Southern Hotel, 1881.) Peter Wight described the floors as being made of "iron rails and concrete," which suggests a slab. (The Brickbuilder vol. 6 (April, 1897), p. 75.)

fire insurance.¹⁸⁷

A notable fireproof building of this decade, constructed in the new style, was the Mitchell Building in Milwaukee (designed by E. Townsend Mix), completed 1878. It was the first to have hollow floor blocks made with Loring's porous terra cotta. The material was used to make skewbacks that wrapped under the beam flange. The rest of the floor arch was made of brick. The columns were Wight's design, partitions were made of hollow blocks, and the roof was made of porous tiles set between T-iron, to which slate and metal covering was nailed, like the roof of the Chicago Water Works. Not coincidentally, it was also "the most costly private building erected in the West for many years."¹⁸⁸

Hollow Tile and Fireproof Buildings in the Business Recovery

As building construction revived at the end of the decade, fireproof buildings began to be built in greater numbers. They also began to become a larger share (although still a minute one) of all buildings, as a greater range types of buildings were coming to be built fireproof, for example stores, warehouses, hotels, factories, and most especially, theaters. While government and institutions continued to be the most stalwart clients for thoroughly fireproof construction, two new kinds of buildings were swelling the numbers of fireproof buildings: office buildings and "apartment houses." Developers of these kinds buildings also tended to select the new fireproof and fire resistant construction methods rather than brick arches, which were becoming obsolete. Of the new systems, the semi-fireproof methods -- the tile-protected type and, to a lesser extent, "mill construction" buildings, which will be discussed in the next chapter -- were probably the most common. But even thoroughly fireproof hollow tile and protected iron buildings began to be built in growing numbers.

Perhaps the most striking evidence of the increased acceptance of the new systems is the growth of the "fireproof building" trade, comprised of the firms that made hollow blocks. In the 1880s, with the exception of HHC, which seems to have left the business,¹⁸⁹ the

¹⁸⁷ Quotes from The New Southern Hotel, 1881, p. 5. In the collection of the Missouri Historical Society.

¹⁸⁸ AABN vol. 3 (Feb. 2, 1878), p. 43; AABN vol. 5 (May 31, 1879), p. 172.

¹⁸⁹ In 1879, Heuvelman & Co. bid on the iron roof for the National Museum in Washington. ("Fire Proof Building, National Museum 1879-1881, Bids and Contracts," Smithsonian Institution archives, Washington, DC.) So apparently HHC had been reorganized.

firms established in the 1870s reorganized and expanded, and several fireproofing companies were established. Johnson had returned to Chicago from New York in the second half of the decade and formed Johnson & Company. After he died in 1879, the business was continued by his partner who in 1880 joined with Johnson's son Ernest to form Ottawa Tile Company, named after the town, west of Chicago, where the company's clay mines and works were located. By the mid-1880s, the company was renamed the Pioneer Fireproof Construction Company.¹⁹⁰ Pioneer's works were substantially mechanized by 1884; water or steam power drove clay crushers, elevators, tile presses.¹⁹¹ Fireproof Building Company of New York announced in 1885 that it was expanding its operations.¹⁹² Other firms entered the business. In the New York area, Henry Maurer & Son, a long established brick manufacturer with works at Perth Amboy, New Jersey, entered the fireproofing market in about 1874, presumably, after Maurer patented a hollow ceiling tile (mentioned above). The Raritan Hollow and Porous Brick Company was incorporated in 1882 with works near Perth Amboy.¹⁹³ It made hollow floor and partition blocks, and also terra cotta lumber. Peter Wight founded The Wight Fire-Proofing Company in about 1881 and established offices both in Chicago and New York. It does not seem to have had its own manufacturing facilities, but rather contracted with tile manufacturers make products to its specifications.¹⁹⁴ Also in New York, John J. Schillinger manufactured fireproof blocks for floor arches, partitions, and furring as well as tiles for protecting wooden beams, apparently made from concrete.¹⁹⁵ Schillinger took out patents for a number of fireproof building products, beginning in 1879, by which time his company had begun to manufacture hollow concrete partition blocks.¹⁹⁶

¹⁹⁰ A. T. Andreas, History of Chicago, pp. 87-88. IA reported in 1884 that the company had changed its name. (IA vol. 3 (Feb., 1884), p. 8.)

¹⁹¹ An article about the company is in IA vol. 4 (August, 1884), advertising supplement.

¹⁹² IA vol. 4 (July, 1885), p. 3.

¹⁹³ Advertisers' Trade Supplement, AABN vol. 24 (Dec. 1, 1888),

¹⁹⁴ For example, the New York Terra Cotta Lumber Company made tile for Wight. (New York Terra Cotta, 1882, p. 34.)

¹⁹⁵ Advertisement in AABN, e.g., Nov. 15, 1884, p. xix.

¹⁹⁶ Patent no.s 213,945 and 221,108 (1879); 233,029 (1880); 252,263, 262,483, 262,284 (1882); 293,523 (1884).

Similar hollow concrete blocks, according to one architect, "are made in most of our large cities."¹⁹⁷ (Illustration 4-11.)

Another important fireproofing element began to be adopted in this decade: beam flange protection. The lesson people of the Chicago fire -- that iron needed to be protected -- seemed to apply to iron columns only. Beams were considered less structurally vital and, for some reason, wrought iron was considered less likely to be injured in a fire than cast iron. Consequently, beam flanges were left uncovered or covered with a thick layer of plaster.¹⁹⁸ But a layer of plaster offered little protection: in a fire, it fell off or was washed off by the firemen. Worse yet, these ceiling developed streaks: plaster laid directly over the iron beams flanges was colder than the plaster over the tiles and attracted soot; also the beams rusted. As mentioned above, as early as 1872, a patent was granted for a floor arch in which the skewback blocks wrapped around the beam flange (both above and below) for the purpose of insulating it.¹⁹⁹ But there is no evidence that this style was used in the 1870s. In 1883, Henry Maurer patented a hollow tile flat floor arch in which the skewback blocks wrapped around the beam flange.²⁰⁰ Maurer's arch was used, and was still in demand in at the end of the century, even though simpler (and therefore less expensive) methods of covering beams were available by then.²⁰¹ Other companies made skewbacks which wrapped under the beam flange. The main drawback to this approach was that the small piece of the block projecting from the bottom of skewback was liable to break. Another means of protecting the lower flange, which Peter Wight patented in 1883, was the *soffit* tile. The soffit tile was a separate piece of tile that covered the bottom of the beam. It was glued with mortar to the bottom of the beam before the arches were set and then held securely against the skewbacks

¹⁹⁷ AABN vol. 6 (Aug. 16, 1879), p. 55.

¹⁹⁸ In the 1870s, even people who should have known better did not consider beam flange protection vital. For example, William J. Fryer, in his textbook on architectural iron work discussed "moulded rolled wrought iron beams," explaining that owners preferred to "leave exposed the lower flanges of the iron beams" and in these cases, beams with moulded bottom flanges "makes a finished appearance." (Architectural Iron Work, p. 125.)

¹⁹⁹ Wear L. Drake's patent, 140,352, Dec. 3, 1872.

²⁰⁰ Patent no. 299,820, Dec. 5, 1883.

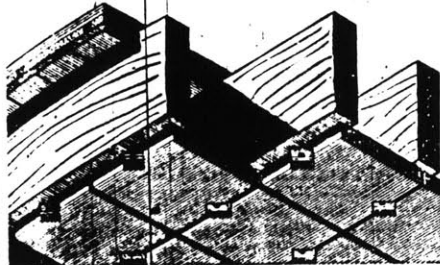
²⁰¹ Peter Wight, The Brickbuilder vol. 6 (May, 1897), p. 98.

Fire-proof Building.

THE WIGHT FIRE-PROOFING COMPANY,
202 La Salle St., CHICAGO, 80 William St., NEW YORK.
CONTRACTORS FOR ALL KINDS OF FIRE-PROOF WORK IN

Porous Terra-Cotta and Hollow Fire-Clay Tiles
IN ALL PARTS OF THE UNITED STATES.

ILLUSTRATION OF POROUS TERRA-COTTA FIRE-PROOF CEILING.



500000 feet of this ceiling have been put up in Chicago, Milwaukee and Cleveland, and it is now being put in the American Bank-Note building, New York.

Patented April 16, 1879, and March 6, 1883.



Top of Ceiling Tile.



Bottom of Ceiling Tile.

All forms of constructive Iron-Work, such as COLUMNS, GIRDERS, and ROOF TRUSSES covered with POROUS TERRA-COTTA and left ready for plastering. Partitions, Furring and Roofing Furnished and Set.

FIRE-PROOF BUILDING MATERIALS.

Raritan Hollow and Porous Brick Company,
Manufacturers of Hollow Burnt-Clay Bricks and Porous Terra-Cotta Bricks, For Floors, Ceilings, Partitions, Furring, Roof-Lining, Column Fire-Proofing, etc.
Office: 115 BROADWAY, New York. Factory, Raritan River, near Perth Amboy, N. J.
EDWARD KEANEY, Pres't. J. C. ROSSI, Sup't. H. M. KEANEY, Sec. and Treas.
Boston Agents: FINKE & COLEMAN, 62 Congress Street.
Estimates Furnished. Builders Supplied. Send for Illustrated Catalogue.

Geo. M. Moulton, Pres't. A. T. Griffin, Vice Pres't. E. V. Johnson, Sec'y, Treas. and Gen'l. Man'g'r.

FIRE-PROOF HOLLOW BUILDING TILE

Fire-Proof protection for Iron and Wood Columns and Girders. Special designs on application.



FOR THE INTERIOR CONSTRUCTION OF BUILDINGS. Great strength, combined with saving in space, and weight, is obtained by the use of our system of Hollow Tile Floors, Partition Walls, Roofs, Ceilings, Etc. Contracts taken for the erection of Hollow, Solid and Porous Tile-Work in any part of the United States.
PIONEER FIRE-PROOF CONSTRUCTION CO.,
1545 CLARK STREET, CHICAGO.
Formerly THE OTTAWA TILE CO.
MANUFACTURERS AND CONTRACTORS, Dealers in every description of constructive Tile for Building Purposes.
Send for our descriptive Catalogue, giving full explanations, advantages, references, etc.

LEONARD F. BECKWITH, Pres't. & Treas. ARTHUR BECKWITH, Sup't. CHARLES E. STREAT, Sec'y.
Established 1873.

THE FIRE-PROOF BUILDING COMPANY,

NEW YORK.
MANUFACTURERS OF FIRE-PROOF BUILDING MATERIALS.
Porous Terra-Cotta Blocks, Hollow Burnt-Clay Bricks and Tall Lime Composition Blocks.
For Arches, Partitions, Furring, Deafening, Roofing, etc.

BUILDERS SUPPLIED.

Office, 229 BROADWAY, (Rooms 12, 13 and 14,) NEW YORK, N. Y.

ESTABLISHED 1856.

HENRY MAURER, Manufacturer of

Fire-Proof Material

Of every description. Hollow Brick made of Clay for Flat Arches, Partitions, Furring, etc. Porous Terra-Cotta, Fire-Brick, etc., etc.
Works, PERTH AMBOY, N. J. Office and Depot, 420 EAST 33d STREET, New York.

LYONS' PATENT FIRE-PROOF

BUILDING MATERIAL,

FRANK LYONS, JR., Sole Manufacturer.

Office Room 60, Drexel Building, Cor. Wall and Broad Sts. Works, Nos. 87 to 95 Clason Ave., Brooklyn. New York Telephone, New 367. Brooklyn Telephone, Williamsburg, 391. Mechanics and Traders' Exchange, No. 11 Vesey St. (Box #2).



The above cut shows the method of applying the sheets of fire-proof material to floor timbers, furrings, etc.

FIRE-PROOF.

MAGNESO CALCITE FIRE-PROOF CO.,
BOSTON, MASS.

Manufacturers of Fire-Proof Material for the protection of buildings. Indorsed by the leading Architects of Boston.

Send for testimonials of actual fire tests. Every information given by application to the principal office.

72 SUDBURY STREET, BOSTON.

FIRE-PROOF FOR WOODEN BEAMS.

Patented August 4, 1882.

Fire-Proof Tiles for Arches, Partitions, and Furring. Also, Tiles for Protecting Wooden Floor Beams against Fire. Artificial Stone and Rock Asphalt pavements.
JOHN J. SCHILLINGER, 426 East 32d Street, NEW YORK.

Terra-Cotta.



Illustrated Catalogue of 100 pages sent to ARCHITECTS, BUILDERS and OWNERS, upon application accompanied by business card.

INDIANAPOLIS
TERRA-COTTA CO.
INDIANAPOLIS, IND.

Manufacturers of
Architectural Terra-Cotta.
Send for estimates.

BALTIMORE
TERRA-COTTA CO.
Office: 80 Columbia St., Baltimore, Md.
MANUFACTURERS OF
ARCHITECTURAL TERRA-COTTA
MOULDED AND PRESSED BRICK.



PERTH AMBOY
TERRA-COTTA CO.
Nos. 80 and 81 Asfor House, New York.

MANUFACTURERS OF
ARCHITECTURAL TERRA-COTTA.
BUFF AND COLDRED BRICK, FIRE BRICK.

A. HALL
TERRA-COTTA CO.
Architectural Terra-Cotta, Fire-Brick, Furnace-Blocks, &c.
MOULDED, BUFF, AND COLORED BUILDING BRICK.
Perth Amboy, N. J.

Northwestern Terra-Cotta Works.
TRUE, BRUNKHORST & CO.,
ARCHITECTURAL

TERRA - COTTA.
Works: Chicago, City Office: Room 20, Corner Clybourn & Wrightwood Aves., McCormick Block. Formerly Cor. W. 15th and Laflin Sts.
Estimates given on application. Send for latest Catalogue, Price-List and Samples.

AUGUST T. CHUR,
Room 14, 5th story, Mills Building, N. York.
Importer of

"WILCOCK'S" Enamelled Bricks,
Impervious to any atmospheric effect, and may be used with perfect safety in the face of moisture and frost.

YOUNG O. WILSON & SON,
Manufacturers of
ARCHITECTURAL TERRA-COTTA.

Best Quality of Plain and Moulded Pressed Brick.
Office, 1 N. Paca Street. Baltimore, Md.

WATER-PROOFING

FOR WALLS
Renders brickwork permanently non-absorbent, prevents weather stains and crumbling mortar-joints; also prevents disintegration of stone without altering the appearance. Can be proved reliable. State-rights for sale under the patent. For full particulars apply to
THEODORE HUNT, 473 North 12th St., St. Louis, Mo.

once they were in place.²⁰² (Illustration 4-12.) Wight first used soffit tiles in the main building of a new building for the Mutual Life Insurance Company in New York (1883-1884, Charles Clinton) and then in all but one of the floor arch projects completed by his company, through 1891.²⁰³ The idea was adopted by other tile makers in the West.²⁰⁴

Illustration 4-12. Tile floor arch with a separate soffit block under the beam.

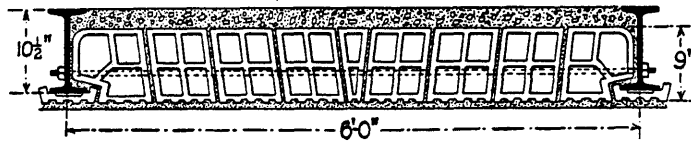


FIG. 5.—Terra-cotta Arch in Mutual Life Insurance Building, New York.

The apparent cost effectiveness of the barrier systems made them very popular for new office buildings in large cities. Much of Beckwith's business was for ceiling tiles made of his concrete compositions. The Wight Fire-proofing Co. featured its ceiling tile, rather than arch blocks, in his advertisements. Examples of this firm's semi-fireproof projects are the Ryerson/Revell Building in Chicago (Adler and Sullivan, 1881-83), the American Bank Note Company Building (c. 1884) in New York, and the Tribune Building (Leroy Buffington, c. 1884) in Minneapolis. An example of Pioneer Fireproof Construction Company's semi-fireproof work was the Calumet in Chicago, designed by Burnham & Root (c. 1882-1884); the floors were wood protected with tiles and the partitions were hollow tile.²⁰⁵ Pioneer's own office building in its yard in Chicago (c. 1884) -- a museum of hollow tile -- had wood

²⁰² Patent no. 285,452, filed March 29, 1883. This idea may have been in use before 1883. Wight describes what sounds like a soffit tile in an 1879 article when he described a system of covering a girder: "the bottom (tile), being dovetailed, can be held by the side block, which are so formed as to admit the dovetailed block." (AABN vol. 5 (May 31, 1879), p. 172.)

²⁰³ Peter Wight, *The Brickbuilder* vol. 6 (May, 1897), p. 98.

²⁰⁴ Peter Wight, "Recent Fireproof Buildings in Chicago, Part III," p. 34.

²⁰⁵ *IA* vol. 3 (Feb., 1884), p. 10.

floors protected with tile plates.²⁰⁶ An 1885 advertisement for Pioneer listed these projects outside of Chicago, which were probably all the semi-fireproof type: Ryan Hotel in St. Paul; West Hotel, Minneapolis; Colby Building, Milwaukee; a floor added to the Stillman Apartment Building, Cleveland; Montgomery Country Court House, Dayton; Gay Building and Equitable Life Insurance Co. Building, St. Louis.²⁰⁷

Iron and tile arch buildings began to make appear in a greater number of cities. Philadelphia's pioneer modern office building, the Wood Building (c. 1881), was built with hollow tile floor arches from Henry Maurer & Son.²⁰⁸ By this decade, too, the federal government opted for hollow tile for its buildings. Wight Fireproofing Company won contracts for many Treasury Department buildings in mid-West cities and for column fireproofing in the new Pension Building in Washington.²⁰⁹ Pioneer too did work on federal buildings, including buildings in Harrisburg, Montgomery, Topeka, Pensacola, and Jackson, Mississippi.²¹⁰

The work of the architect Adolf Cluss in Washington in the early 1880s illustrates the transition from brick arches to hollow tile. Cluss designed and superintended the reconstruction of the eastern wing of the original Smithsonian building in Washington, which was not fireproof. It was rebuilt between 1883-1884 with iron beams and brick arches. However, some of the new technology was used in this building: parts of a new roof on the western section of the building was made with hollow tiles.²¹¹ Likewise, in the mid-1880s, when Cluss reconstructed the south wing of the Patent Office building following a fire in the building, he used porous terra cotta to protect the iron roof framework. The lower parts of the beams were covered with tile. An arch was laid above this, flush with the top of the beams, much like a hollow tile floor except that the arch spanned from beam to beam rather

²⁰⁶ IA vol. 4 (August, 1884), p. 12.

²⁰⁷ IA vol. 5 (July, 1885).

²⁰⁸ Edwin Betolett, "Fireproof Construction in Philadelphia," Insurance Engineering vol. 2 (1901).

²⁰⁹ IA vol. 3 (July, 1884), p. 82.

²¹⁰ IA vol. 5 (July, 1885).

²¹¹ "Report of the Architects for the Reconstruction of the Eastern Portion of the Smithsonian Institution," Annual Report of the Board of Regents for 1884 (Washington: G.P.O.), p. xxi.

than between joists carried by beams.²¹²

In early 1885, Wight wrote an article about the recent increase in the number of fireproof buildings in Chicago.²¹³ Since "improved methods of fireproofing" were introduced in about 1881, eighteen fireproof buildings had been built or were under construction in Chicago. Nine were to be completed in 1885 and of these, the majority (six) were iron and tile (three were wood frame and tile).

What was tipping the scales c. 1883-84 in favor of the more expensive iron and tile system? One factor was the appearance of new kinds of buildings, ones that owners were more than commonly likely to build fireproof. The new kinds of buildings were apartment houses and office buildings. While there had long been multi-unit residences for the poor in large cities, such buildings for middle-class families were a new thing in the U.S. They gained legitimacy by being fashionable residences in Paris, where they were built along boulevards during the redevelopment of that city under Baron Haussmann in the 1850s and 1860s. What is usually considered America's first, the Stuyvesant in New York, was built in 1869. One feature of apartment houses that distinguished them from tenement houses was greater provisions for fire protection -- fireproof floors and partitions -- which the owners introduced voluntarily in order to attract buyers and tenants.²¹⁴

The office building of the 1870s also was a comparatively new sort of structure. Unlike the buildings put up by insurance companies, banks, and publishers, in which they occupied some floors and rented the rest, the new generation of office buildings were built entirely, or mainly, for rent or resale. Even in owner-occupied buildings, most of the space was rented out. To attract tenants, the new office buildings included passenger elevators and structural fire protection. The elevators and fire protection made the higher floors, which formerly were the least desirable, appealing to tenants. Moreover, improvements in mass

²¹² Peter Wight, The Brickbuilder vol. 6 (April, 1897), p. 75. The tiles were made by Henry Maurer in New York.

²¹³ Peter Wight, "Recent Fireproof Building in Chicago," IA vol. 5, extra no. (April, 1885), pp. 52-53.

²¹⁴ History of Real Estate ... in New York City, p. 395, lists New York apartment buildings with fireproof floors: Dakota (c. 1884), Chelsea (c. 1883), Spanish Flats (c. 1883), Shoreham, Grosvenor, Osborne (c. 1885), Nevada, Knickerbocker, Grenoble, Yosemite, Randolph, Bereford, Earls court, Gramercy Park and Florence.

transit, which enabled office workers and customers to actually get into traffic-congested parts of town where the buildings were constructed, made the continued concentration of office activities there feasible.

Another novel feature of these office buildings was their height. While they were hardly the typical building, ten and twelve stories began to sprout up in New York and Chicago. Above a certain height, iron and hollow tile were the only practical materials of construction. Iron posts were needed in order not to have unsightly forests of posts and piers and walls of massive dimensions. Hollow tile was equally vital to building tall. As suggested above, the comparative lightness of hollow tile floors may have been welcome but whether designers of small buildings were able to realize savings in materials because of them is unclear. For tall buildings, designers were keen to save weight, because the total loads could become tremendous. Hollow tile was a significant advantage in a tall building with many floors. A very tall building could no more have weighty brick arch floors than it could have wooden posts, and the increase in the number of tall buildings increased demand for hollow tile. Peter Wight suggested that it was precisely because the materials for the fireproof buildings were so expensive, that the owners were obliged to put up as much building as possible in order to make them pay. As he explained the connection in 1893,

In order to build fireproof structures and make them pay, they must be many stories higher, so as to decrease the relative cost of the land to the improvement. Building higher on compressible soils necessitated economy in weights. Hollow materials *only* made this feasible.²¹⁵

The number of fireproof buildings grew not only because of changes in the kinds of buildings that were being built -- i.e., more buildings of the types that was likely to be built fireproof, therefore more fireproof buildings -- but in part due to changes on the supply side, which may have reduced the cost of building them. The change occurred in construction costs, not, for example, in the price of structural metal. In fact, in the early 1880s, even though steel production was increasing to the point where it soon supplanted iron for railroad rails, the price of iron beams remained high and no American steel beams had yet been used in a building. Contemporaries attributed the high cost of beams to price fixing by the

²¹⁵ "Fireproof Construction and the Practice of American Architects," AABN vol. 41 (Aug. 19, 1893), p. 114.

manufacturers, the oft complained of "mill pool," as well as tariffs on imported beams. However, bridge builders began to bid on contracts to erect structural iron in buildings. Before this time, as discussed in the previous chapter, architectural iron works were the usual contractors for building the iron frame.

Bridge shops, which made iron bridges, entered the world of building after the Civil War, initially by constructing iron roofs. As previously mentioned, New York's 1871 building required that Mansard roofs under certain conditions be built fireproof, and Boston's amended 1872 law required that all multi-story roofs and all roofs on tall buildings be fireproof. In both cases, this meant the roof had to be framed in iron and covered with some noncombustible material.²¹⁶ Unlike wood roofs, which would have been built by a carpenter or house builder, iron roofs were manufactured, installed, and sometimes designed by an iron builder. Bridge companies that made truss bridges and also roof trusses, began to bid on iron work in buildings, meaning the columns and beams, which up to this time had been the province of foundries. That architectural iron works considered bridge companies interlopers is indicated in the case of the New York post office in the early 1870s. The low bidder for some of the iron work for this building was the Kellogg Bridge Company of Buffalo, New York, which alarmed another bidder, Architectural Iron Works (AIW) in New York. After learning that Kellogg was the low bidder, Nathaniel Cheney, vice-president of AIW, complained to the Supervising Architect of the U.S. Treasury that he did not expect to have to compete with bridge builders, and he doubted Kellogg could make the ornamental work for this building, "being only prepared for making Bridge Work which requires only the coarsest kind of Iron Work." He noted that his bid was lowest of those "engaged in the business," meaning the established architectural iron works.²¹⁷ Nevertheless, Kellogg was awarded the contract and apparently executed it successfully, although the building itself was

²¹⁶ "Extracts from the Building Law of the City of New York (passed April 20, 1871)," section 13, in William Fryer, Jr., Architectural Iron Work, p. 156; Chapter 317 of Massachusetts laws of 1872, sections 19 and 20.

²¹⁷ Nathaniel Cheney to Alfred Mullett, November 9, 1871, New York Post Office, National Archives, RG 121, entry 26, box 310.

fraught with problems, not, however, the fault of the contractors.²¹⁸ Bridge companies became increasingly important in the construction of fireproof buildings when, in the next decade, the price of structural shapes finally dropped and entire building frames began to be made of steel.

The Fireproof Skyscraper

Fireproof buildings were not necessarily tall, but tall buildings almost invariably were fireproof. The iron and tile buildings scattered around the nation were all noncombustible buildings, not merely for the sake of fire safety, but out of structural necessity. It was the tendency to build office buildings tall, as suggested above, that shifted the proportion of fireproof buildings to the iron and tile system, and that eventually doomed the semi-fireproof systems as a option for office buildings. The shift to hollow tile probably was adopted more universally in New York than Chicago. As of 1884, the architect Theodore M. Clark explained to the Society of Arts in Boston -- a city where hollow tile was probably almost unknown at the time -- that New York was the center of advance in thoroughly fireproof buildings, and there "for floors, burnt clay is now universally used in the shape of blocks, made hollow, to save weight, and tapered so as to form a flat arch.... The old-fashioned brick arches, turned upon the lower flanges of iron beams, have now entirely disappeared from ordinary work, except for carrying sidewalks over coal vaults."²¹⁹

In Chicago, the shift was not complete by 1885, but the developments there are easier to chart. The first really tall building in Chicago -- the one that thrilled a young building tradesman who had recently emigrated from Sweden and future Building Commissioner, Henry Ericsson -- was the nine story Montauk block, completed in 1882.²²⁰ It was designed by Daniel Burnham and John Root, soon to be among the most prominent architects in that city, with Peter Wight as consulting architect and then hollow tile contractor for the floor arches and columns in the building. One of the historic constraints on building height in Chicago was that the soil underlying the business center of the city, called the Loop, was

²¹⁸ For example, the roof collapsed. (Engineering News (May 19, 1877), p. 125.)

²¹⁹ Speech reprinted in AABN vol.16 (Nov. 15, 1884), p. 232.

²²⁰ Henry Ericsson, Sixty Years a Builder.

sandy and compressible. Bedrock is so far below the surface that local builders learned to build foundations on a stratum of stiff clay called "hard pan," found about 12 to 15 feet below the surface.²²¹ The higher a building got, the more, potentially, it weighed and yet all buildings, before the era of deep foundations, had to be carried on the hard pan layer. Thus, the challenges in constructing a large, heavy building like the Montauk were to lighten the superstructure and create suitable foundations that did not pierce the hard pan. Wight designed flat floor arches for this building made solid of fire-clay with very thin (half inch) walls. The blocks were strengthened with interior webs. The result was a light -- only 25 pounds per superficial foot, compared with about 70 for brick arches filled with concrete -- and strong floor.²²² However, the tile arch was of short span -- only three to four feet between beams -- and so the floor necessitated many beams.²²³

As previously mentioned, in 1885, three of the nine fireproof buildings then being completed were of the tile protected wood type. The use of this system apparently ended abruptly in that year, after the Grannis Block was destroyed by fire. The Grannis, designed by Burnham & Root (1880-81) and fireproofed by Pioneer, was a much admired building: with its red brick and terra cotta walls, it stood out against the stone veneered buildings prevalent in Chicago. No contemporary suggested that the Grannis, with wood floors and cast iron columns fireproofed with tile, was not a good example of the semi-fireproof style of building. This made its destruction all the more shocking and convinced many people that a wood and tile building was a false economy. For example, an editorial in Inland Architect (IA) about the fire concluded, "There is fortunately no division of opinion upon the advisability of fire-proofing such structures, as the owners now see that a sum not exceeding \$20,000 would have thoroughly fireproofed this splendid building, that cost upward of \$200,000."²²⁴

²²¹ Edward Shankland, "Steel Skeleton Construction in Chicago," IA vol. 30 (Jan., 1898), p. 56; Ralph B. Peck, History of Building Foundations in Chicago, U. of Illinois Engineering Experiment Stations, Bulletin Series, No. 373 (Urbana: U. of Illinois, 1948).

²²² Peter Wight, The Brickbuilder vol. 6 (April, 1897), p. 75.

²²³ Peter Wight, "Recent Fireproof Buildings in Chicago, Part III," IA vol. 19 (April, 1892), p. 34.

²²⁴ IA vol. 5 (March, 1885).

Henry Ericsson joined the throngs gaping at the "spectacle of the Grannis Building, underneath its glistening sheath of ice, a ruin from the fire," and recalled its impact, "In a real sense, more was learned from the burning of the Grannis than from the great fire of 1871; at least, its lessons were taken to heart and tenants became aware and alert as regards the perils of fire."²²⁵ Ericsson felt that tenant preferences were influential in encouraging owners to build fireproof. "Banks that occupied its (the Grannis') first floor ... to say nothing of other highly preferred tenants, would never again take leases upon the appearance of the exterior of a building."²²⁶

Were tenants willing to pay a premium for renting in fireproof buildings and did this have the effect of making them more profitable to build? Unfortunately, the information is not available to answer this question. But even if owners of fireproof buildings could not charge more rent, they may have been able to attract better tenants and better terms, which would have been valuable. Whatever effect consumers may have had in influencing the choices of owners, it soon could have affected only smaller buildings, because cities began to require that tall buildings be built thoroughly fireproof.

Even for small buildings, some constructors put into effect the lessons of the Grannis. In Madison, Wisconsin, Science Hall at the University of Wisconsin burned down at the end of 1884 and replacement plans called for "a substantially fireproof building." In the course of constructing a replacement building, the construction superintendent, a member of the engineering faculty, changed the plans from "'slow-burning' to 'fire-proof,' involving the use of more iron, steel, tile, brick and stone -- and more expense," for which he was heavily criticized. The building was begun in 1885 and completed late 1887.²²⁷

The Grannis fire had not been the tide-turning experience for Peter Wight, but eight years and fires in several of this type of building later persuaded him that noncombustible materials were worth the expense. One such fire occurred in the Lumber Exchange building in Minneapolis in 1891. The Lumber Exchange building consisted of two parts: an older,

²²⁵ Henry Ericsson, Sixty Years a Builder, p. 88 and p. 213.

²²⁶ Henry Ericsson, Sixty Years a Builder, p. 219.

²²⁷ Clarence Olmstead, Science Hall, the First Century Department of Geography, U. of Wisconsin, December, 1987, p. 5.

nine story, semi-fireproof section and a new (not yet complete) eleven story fireproof section. The fire, which started in a wholesale paint store on the same block as the Exchange, broke into the Exchange and burned for a day. The old section was gutted but the newer part was uninjured. Moreover, a third building on the block, the Edison Light building, was an iron and hollow tile building, and was uninjured. The old section of the Lumber Exchange was rebuilt with hollow tile.²²⁸ Another semi-fireproof Minneapolis building, the Tribune, which Wight had fireproofed, also burned. By 1893, even Wight was advising against using semi-fireproof construction: "It is not always reliable and we have had experience to lead to this conclusion."²²⁹

"Fireproofing," Not Fireproof

The main advance in this period was technical: the development of materials for insulating structural iron that were both light weight and also withstood fire and water. Before the great fires in Chicago and Boston, a fireproof building was a noncombustible building. After the fire, experts began to define a fireproof building as one in which the materials of construction were not only noncombustible but also non-conducting. Peter Wight summarized the new understanding in 1879, explaining that despite what was once supposed and what some architects continued to believe, "it is one of the latest developments of the art of building that fire-proofing depends more upon the *protection* of the materials of construction than upon the materials themselves."²³⁰

By the middle of the 1880s, the new products were well established. Fired clay was the standard material for structural blocks. A half a dozen companies, at least, manufactured hollow tile for fireproof construction. Fireproof blocks were now made principally with hard (solid) or porous tile. Concrete had fallen out of favor as a material for building blocks because the products of some manufacturers had not withstood fire and water well.²³¹ Floor blocks were made in a great variety of shapes: heavy, light, with or without interior webs,

²²⁸ IA vol. 18 (August, 1891), pp. 7-11.

²²⁹ AABN vol. 41 (Aug. 19, 1893), pp. 114-115.

²³⁰ AABN vol. 5 (May 31, 1879), p. 171.

²³¹ T. M. Clark, AABN vol. 16 (Nov. 11, 1884), p. 232.

flat or curved arches. Tiles were made for roofs, for column and beam flange covering, for partitions. Fireproof blocks were by no means a commodity, but they would become one.

To satisfy customers that their tile arches would perform as required, manufacturers continued to conduct tests and demonstrations. To show the strength of its arch tile floors, Wight Fireproofing Company loaded sections of the floors it had installed in the Chicago Chamber of Commerce Building with cases of dry goods, timber and bricks; raised and dropped the cases on the floor; and rolled around a 4,000 pound safe. Two further tests, intending to find the weight that would break the arch, were discontinued when it became impractical to load the arches further. The arches did not break under substantial loads. They were witnessed by several prominent Chicago architects.²³² In the absence of independent testing laboratories capable of testing all kinds of materials, these tests were the most potential customers had to go on. Another reassuring indicator of the security of the arches was that they were installed in an increasing number of buildings, so owners could get a more or less proven product.

The number of mills supplying rolled structural shapes had increased and iron beams also were imported. The rolled beam shaped like an I had become the standard section. Since rolled beams were available in large sizes, girders were made by combined I beams and cast iron was no longer used for girders.²³³ Bridge shops were bidding on iron work contracts for buildings. While fireproof construction continued to be expensive, owners found that they could make their investment pay by building taller.

Nevertheless while an increasing variety of buildings were being constructed fireproof, they were hardly the predominant type, even in New York. In Boston in 1894, for example, iron and tile buildings were "so rare that each one is looked upon by the public as an expensive curiosity."²³⁴

What was an owner interested in greater safety, but reluctant to invest in an iron and

²³² IA vol. 3 (June, 1884), p. 64.

²³³ P. Wight, AABN vol. 5 (May 31, 1879), p. 172, "all iron floor-beams now used are of the same section ... and are known as I beams," and "Girders are generally made by places two I-beams together."

²³⁴ John R. Freeman, "Fire Protection Engineering," lecture notes, c. 1894, JRF papers, M.I.T. Archives, box 29.

tile building, to do? He could use the "semi-fireproof" system of ordinary construction protected with tile. Or he could take the advice of factory fire insurance officials and construct a building based on the system developed for New England textile mills, which "will almost rival the brick-and-iron floor (building) in its fire resisting qualities."²³⁵ In the 1880s and 1890s, what became known as "slow-burning construction" came into its own as an alternative to iron and tile.

²³⁵ John R. Freeman, "Fire Protection Engineering," lecture notes, c. 1894, JRF papers, M.I.T. Archives, box 29.

Chapter 5.

Mill Fire Protection Methods Enter the Mainstream

Introduction

The iron and brick arch system of construction originated in Great Britain specifically for fire-prone cotton factories, yet it was seldom adopted by American textile manufacturers. In the volatile and competitive textile industry, investors were unwilling to make a large investment in a building. Iron and brick factories were rare even in Britain in the first half of the nineteenth century: only the best capitalized manufacturers built fireproof mills. Less affluent owners constructed at most only certain sections of their plants fireproof, such as the very hazardous picker room, where raw cotton and wool was combed, or the rooms with valuable machinery and stock.¹ In the U.S., textile mill owners practically never built in iron and brick; this system was rarely adopted for manufacturing plants of any kind, the odd sugar factory, gas works, and military facility excepted.² This was true even in the latter decades of the nineteenth century, when, as we have seen, the system began to be used to an increasing extent for city office buildings, even though such buildings were at much less risk

¹ Keith A. Falconer, "Fireproof Mills -- The Widening Perspectives," Industrial Archaeology Review vol. 16 no. 1 (Autumn, 1993), pp. 15-16.

² I have searched hard for iron and brick industrial buildings and have found only a few. In chronological order, they are: 1) the printing house of Manchester Print Works (c. 1854), demolished; 2) the picker house for Henry Clay Mill, now part of the Hagley Museum (c. 1860); 3) the main building of Colt's Armory in Hartford (1866-68); 4) buildings at the old Brown & Sharpe Manufacturing Co. works in Providence, R. I. (Building #1, the first section, was built c. 1870-1872); 5) the extension to the Water Shops of the U.S. Armory in Springfield, Mass. (c. 1900). Reference to 1, 3 and 4 in John R. Freeman, "Comparison of English and American Types of Factory Construction," Journal of the Assn. of Engineering Societies vol. 10 (1890). Through a variety of sources and personal inspections, I have been able to confirm that these buildings were indeed of iron and brick fireproof construction.

Sometimes nineteenth century sources mention industrial buildings that may have been fireproof: a mill "built of stone, with arched brick floors" and another "with iron beams." (AABN vol. 6 (Sept. 20, 1879), p. 94.) A reference to "over a dozen breweries and other cold storage houses built of brick or stone, with cement and brick floors resting on iron girders" in Boston and "over 100" of such structures in New York is intriguing, but none of the buildings are identified. (AABN vol. 6 (Oct. 18, 1879), p. 127.)

of catching fire than the average factory.

Fires were a fact of life in textile mills. The challenge for manufacturers was, on the one hand, to prevent fires from breaking out by eliminating their causes and on the other, to limit their destructiveness. With respect to the latter issue, fire protection, manufacturers attempted to make their buildings at least more fire resistant, since cost ruled out making buildings fireproof. They succeeded in developing a system of fire resistant construction that was for a time one of the principal alternatives to "absolutely" fireproof construction.

The system was called "mill construction" or, more descriptively, "slow-burning construction." The system produced a building that was well adapted to manufacturing, fire resistant, and low cost, "the best fitness of means to ends in the effort to reduce the cost of production to its lowest terms."³ It evolved over decades of trial and error, of borrowing and adapting, by textile mill designers, builders, and owners in New England. This empirical process of development probably would have continued throughout the century had not the mutual fire insurance companies that covered a large share of New England's textile mills attempted to put their underwriting standards on a scientific basis. Around 1880, the mill mutuals formalized what had been an informal and not rigorous practice of educating policyholders about how to improve fire safety in their properties. Along with increased technical assistance came research into the best -- most effective for their cost -- methods of reducing the incidence of fire and the likely damage once a fire started. The research findings in turn led to standards for buildings, which were conditions for getting insurance coverage from the mill mutual companies. Adherence to the conditions was assured through periodic surveys by company inspectors.

The ideas on the best mill were expressed in what was called a "standard" mill. Henceforth the best mills would no longer be the product of trial and error, but of research conducted for and by the mill mutual companies and practices tested and approved by the

³ Charles J. H. Woodbury, "Methods of Reducing Fire Loss," Cassier's Magazine vol. 1 (Nov., 1891-April, 1892), p. 29.

companies.⁴ Thus, in the last two decades of the century, at the same time fireproof construction was undergoing substantial development and improvement in the world of commercial architecture, the mill world worked on its own low cost alternative.

We have seen, from the popularity of the semi-fireproof system, that commercial property owners also found fireproof construction unaffordable and presumably would have been interested in the comparatively low-cost, slow-burning methods. But first they had to find out about the system. Since the men who designed commercial, institutional, and residential buildings rarely designed factories, they would have been unlikely to learn about the mill system in the usual course of things. Had it not been for Edward Atkinson (1827-1905), president of the largest of the mill mutual companies for twenty-seven years, the mill mutual approach to underwriting, its construction standards and research results, might have been a boon merely to mill mutual members. Atkinson -- a hard-money man, free trader, pacifist, anti-imperialist, feminist, and tireless pamphleteer -- added safer building construction to his many causes. As soon as he became president of Boston Manufacturers Mutual Fire Insurance Company (BMMFIC) in 1878, he began to issue reports and advisory "circulars," which also served as venues for his "anti-combustion mission." He brought the mill mutuals into a more formal association, which came to be known as the Associated Factory Mutual Fire Insurance Companies (AFM), in order to make standards more uniform. Through the BMMFIC publications, his other writing and speeches, Atkinson spread the knowledge of AFM engineers and officials, who were among the nation's early fire protection

⁴ This topic of the evolution of mill architecture was treated by Betsy Bahr, New England Mill Engineering: Rationalization and Reform in Textile Mill Design, 1790-1920 PhD dissertation, University of Delaware, 1987. My focus is on how the approach of the AFM companies influenced the evolution of fire resisting buildings overall, while Ms. Bahr's concern was AFM's influence on the design of industrial buildings. However, I inevitably cover much of the same ground she did, especially her chapter 4. Another history of AFM and mill design is John J. Crnkovich, "The New England Mutuals' Influence on Industrial Architecture," (dated January 1978, unpublished; copy at the National Museum of American History).

authorities, beyond the insular world of New England textile manufacturers.⁵

Architects and builders around the nation began to construct city buildings according to the principles Atkinson urged. But the heyday of the slow-burning system was brief, lasting roughly only until the turn of the century, after which it began to be used less and less for any kind of building. As a system for building mills, it was superseded by reinforced concrete, which was better suited to new manufacturing conditions. For city buildings, for a number of reasons which will be discussed more in the next chapter, thoroughly fireproof construction became the dominant system.

The demise of the slow-burning system for urban buildings was also hastened by an active campaign against the system. Ironically, this fight was waged by some members of the emerging field of fire protection engineering, who considered slow-burning construction a phony solution to the fire safety problem and, as such, an obstacle to real reform. They believed that for buildings in dense city centers, noncombustible construction was the only acceptable kind.

Although the use of the slow-burning system declined, the system left an important legacy for the safety of all kinds of building. Moreover, the systematic approach to loss prevention developed by the AFM companies was emulated by the stock fire insurance industry, with salutary consequences for the quality and safety of buildings.

"Slow-burning" Defined

With the possible exception of theaters, mills, especially cotton mills, were the most

⁵ Dane Yorke, author of a history of BMMFIC, gives Atkinson principal credit for publicizing the slow-burning system. Yorke had access to company records that apparently are no longer available (BMMFIC is defunct). (Able Men of Boston ... the ... story of ... the Boston Manufacturers Mutual Fire Insurance Company (Boston: BMMFIC, 1950).) On the other hand, Harold Williamson, in his 1934 biography of Atkinson, does not try to calculate Atkinson's influence on the fields of fire insurance and fire prevention, although he did believe it had been "considerable in securing a more widespread adoption of safer building construction and better fire protection." (p. 133.) (Edward Atkinson, The Biography of an American Liberal 1827-1905 (Boston: Old Corner Bookstore, 1934).) But from the perspective of the insurance industry, and not just the man himself, it is clear to me that Atkinson was very influential. Atkinson's personal papers and the statements of contemporaries provide independent support for this conclusion. Incidentally, Atkinson wrote that he coined the term "slow-burning construction." (AABN vol. 40 (April 1, 1983), p. 14.)

hazardous of buildings. Cotton stock was highly combustible and the processes involved in preparing the stock for spinning -- breaking, picking, and carding -- were particularly hazardous operations. Cotton particles, which filled the air when bales were opened, could explode spontaneously. Wire or debris in the raw cotton could strike sparks when they hit the metal teeth in picker machines and ignite the stock. For this reason picking rooms were often separated from the mills. Fires also might start spontaneously from the chemical processes used in dying fabric. Machines were powered by belts or ropes and friction from the drives set off sparks. Artificial illumination, which until the latter part of the century necessarily involved flames, also caused fires. It was to reduce the possibility of fire from gas lights and lanterns that the work day in mills was shorter in the winter than in summer. Owners endeavored to safeguard their properties but in a cost effective way, using traditional rather than the noncombustible materials of the fireproof building. The solution came to be called "slow-burning."

Like semi-fireproof buildings, slow-burning mills had exterior bearing walls of brick or stone and internal frames of wood. Probably more so than the semi-fireproof buildings, vertical spaces in slow-burning mills were strictly compartmentalized, separated from horizontal spaces by walls and coverings over openings, in order to prevent a fire that started on one floor from spreading rapidly across a floor and rising to upper floors. What made the wooden frame of the mill system slow-burning was that the wood was massed and of large size. Experience showed that large dimension timber would burn slowly; indeed, it would char to a certain depth and the charcoal would actually insulate the wood and allow it to keep its strength for a long period. Thus, rather than small, closely spaced joists in a floor made of thin boards, thick plank (three or four inches thick) was laid directly on beams that ran widthwise across the building, from outside wall to inside posts to opposite wall. A groove was made lengthwise along the depth of the plank and filled with strips of wood; this filling prevented gaps from developing as the wood dried and shrank over time. Depending on when a mill was constructed, the floor might have a covering of mortar or building paper, and then one inch boards, which made the walking surface. From underneath, the floor made a flat ceiling and it was generally not covered or finished. (Illustration 5-1.) In fact, concealed spaces -- such as are formed when a lath and plaster ceiling is put underneath an ordinary

joisted floor -- were avoided in slow-burning construction.

Although it was only one ingredient of the system, the feature of mill construction that defined it for lay people was the floors. The dense floor was found to resist fire well; although the elements were wood, they were of large size or so tightly jointed that no air could pass through and so would burn slowly. The roof of a standard mill was built much like the floors. The simple girder and floor construction of the slow-burning mill, incidently, was similar to that of the English fireproof textile mills, but in England the girders were iron and the floors brick arches or, at the end of the century, concrete.

Since wood could eventually burn through, another essential feature of the slow-burning system was fire suppression equipment: buckets of water, piped water and hydrants, and sprinklers. Typically, internal water was supplied by a tank on the roof, which was kept full by pumps. Most mills had a ready source of water in the river that supplied the mill's power. This water was also supplemented by private reservoirs or ponds. Many mills had their own fire brigades made up of mill workers. Probably all workers learned soon enough how to grab one of the pails of water that were distributed around well-run mills and douse a fire. One of the advantages of the joist-less mill floor with its flat ceiling between widely spaced girders was that it could be easily swept with hose streams and spray from sprinklers.

The standard mill, therefore, achieved greater fire resistance using traditional construction materials. Between the compartmentalization and the fire extinguishing equipment, a fire on the inside could be contained and extinguished before it could make much headway. The slow-burning mill thereby accomplished the objective of structural fire protection without the expense of using noncombustible materials. AFM underwriters believed that properly constructed, slow-burning mills were as effective in reducing fire loss as the fireproof mills of England. Proof of this was the very low fire insurance rates AFM members paid.

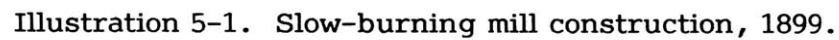
The mill underwriters also saw virtue in necessity, with implications for the nation as a whole. Why build fireproof if slow-burning buildings accomplished the same goals at a lower cost? As one fire protection engineer expressed it,

many of the economists who grieve over [the annual loss to fire] and many friends across the water who view the magnificent public fire departments of some of our

STANDARD MILL CONSTRUCTION.

Eleventh Edition, ~~June 1, 1899~~

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America cities a monuments to the recklessness of our architecture, forget that it is not much worse to burn up a dollar than to bury it beyond circulation in an over-expensive incombustible structure.⁶

But while slow-burning buildings were cheap compared with fireproof buildings, they still cost more -- how much more was a disputed point -- than ordinary ones. Moreover, all of the principles of the system had to be observed for the buildings to perform optimally. In other words, the use of one or another feature of the system would not make a building marginally better, a fact that inexperienced architects who tried to make their buildings slow-burning often failed to appreciate. Also, the system also was not suitable for all kinds of buildings. The inappropriate application of the system, and inexpert design of the "so-called slow-burning" buildings, helped discredit the system.

Origin of the Factory Mutual Fire Insurance Companies

Since much of this chapter concerns the fire insurance industry, it may be useful to begin with a definition of insurance. Insurance is a scheme for distributing an accidental economic loss over a large number of individuals at risk for such a loss.⁷ Within the group over which the loss is distributed, the incidence of loss should be reasonably predictable, but exactly who would suffer the loss in any year would be unknown. Insurance companies in the nineteenth century tended to specialize in one line of business: life, marine, fire, and so on. Also, a fire insurance policy covered losses due to fire only; it was not like today's homeowners property and casualty insurance policy, for example, which covers a variety of losses. Although many insurance companies do business across state lines, fire insurance companies were, and still are, regulated -- chartered and supervised -- by states and not the federal government.

Fire insurance was a latecomer to the insurance field in the United States, appearing long after marine insurance. The usual way a colonial homeowner recovered after a fire was

⁶ J. R. Freeman, "Fire Protection Engineering," lecture notes, J. R. F. papers, M.I.T. Archives, box 29.

⁷ Definition from Spencer Kimball, Insurance and Public Policy: A Study in the Legal Implementation of Social and Economic Public Policy, Based on Wisconsin Records 1835-1959 (Madison: U. of Wisconsin Press, 1960), p. 5.

by appealing to the community for aid. A few domestic (i.e., not British) fire insurance companies started up in the eighteenth century, but the industry did not really begin to grow until the nineteenth century, at which time the number of companies increased rapidly.

American insurance companies fall into two main categories, mutual and stock, which are distinguished by their form of ownership.⁸ Mutual companies are owned by the policy holders while stock companies are owned by the individuals who provide the capital. In a mutual company, income in excess of expenses can be passed on the members in rate reductions or rebates. In a stock company, this excess income would be profit, available for distribution to the stockholders as dividends. Both types of company wish to reduce the amount they must spend to cover fire losses. But the incentives to reduce these costs were greater in the mutual form of ownership since members benefited directly, whereas stock companies could manage profitably taking any sort of *risk*, as long as it priced its indemnity policy accurately and competitively. (Risk is the insurance industry term for a building.) The differences in ownership create economic incentives that also distinguish the companies. Profits in the stock companies -- the difference between the income (the sum of premiums and investment income) and expenses (losses, administration, taxes, and reserves) -- are paid out to investors as dividends; also, the investors' capital is used to pay for claims should income and reserves be insufficient. But in a mutual company, profits, as defined above, are supposed to be returned to members in the form of rebates or lower premiums. While both kinds of companies preferred to accept the best risks, the incentives for the mutuals to do so were even greater than for the stock fire insurance companies. The stock companies theoretically could always come out ahead as long as they priced their product correctly. But the mutuals sought to avoid loss altogether in order to keep members' premiums as low as possible. The strategy of pooling "preferred risks" in order to limit losses is a longstanding one: the Philadelphia Contributionship, probably the first American mutual company, would not insure houses with trees growing near them, fearing, presumably, that fire could spread

⁸ Individual underwriting, of which Lloyds of London is the best known representative, was rare.

from trees to buildings.⁹ Thus, the mutual companies set criteria, however rudimentary, that policyholders had to meet. Stock companies, on the other hand, would insure property in whatever condition they found it in, and set a rate of premium accordingly.

Both stock and mutual companies are equally old; some of the first fire insurance companies in the U.S., found in Massachusetts, New York, and Pennsylvania, were mutuals.¹⁰ An 1835 law in Massachusetts regulating mutual fire insurance companies chartered in that state gives a sense of what mutuals were like in the early history of the industry. The law required that every policyholder be a member of the company; that members elect directors; and that members cover losses, although their liability was limited. Reserves consisted of notes backed by members' buildings and other property. The directors ultimately were responsible for seeing that all legitimate claims were met, and their liability was not limited.¹¹ This general establishment law said nothing about what kind of property a company could accept; in Massachusetts, this was specified in each company's charter.

Since the means for keeping members' costs low was to minimize losses, mutual companies tended to cover not only the best properties, but also low risk ones, like homes. In contrast, the Factory Mutuals were established to cover high risk properties -- mills and associated buildings -- and only these properties.¹² This specialization was unprecedented in both the stock and mutual fire insurance fields, and the origin of these companies requires explanation.

Several excellent histories have been written about various AFM companies none of

⁹ The Fire Association, A Short Account of the Origin and Development of Fire Insurance in Philadelphia (Boston: The Fire Association, 1917).

¹⁰ Osborne Howes, Jr., "The Rise and Progress of Insurance in Boston," in Justin Winsor, ed., The Memorial History of Boston vol. 4 (1883), pp. 179-194; F. C. Oviatt, "Historical Study of Fire Insurance in the United States," 1905, reprinted in Kailin Tuan, ed., Modern Insurance Theory and Education vol. 1 (Orange, N.J.: Varsity Press, 1972).

¹¹ Commonwealth of Massachusetts, Chapter 147 of Laws of 1835, "An Act to regulate Mutual Fire Insurance Companies."

¹² Dane Yorke concludes that "the real novelty of Zachariah Allen's approach to mutual fire insurance was that he planned his company for manufacturers only." (Dane Yorke, Able Men, p. 30.)

which seem to consider it remarkable that these companies exist at all. All note that the first company was founded in a period of economic turmoil, 1834-35, when fire insurance rates were on the rise, as if this was reason enough.¹³ But for cotton mills, insurance rates were high even in good times. What especially exasperated some owners, notably Zachariah Allen, was that the stock companies refused to reduce rates for mills that were better than average. The industry's approach at the time to setting rates was to establish classes of properties (for location and use of the building) and set rates for the class. What belonged in a class, and what rate was charged for the class, was based on tradition and judgment (critics said guesswork), not on historical loss experience and certainly not broad-based statistics, since such information simply did not exist. While in the case of some buildings, such as cotton mills, additions might be made to the basic rate for negative features of a property, deductions from the base rate were not granted for "good" features.¹⁴ As Allen, who became one of the founders of a mill mutual, recalled in his autobiography, he could not get an insurance company agent to come to his mill to see the fire protection measures he had installed, since insurance companies did not routinely inspect risks.¹⁵ Thus, some owners hatched the idea of establishing a mutual insurance company for high quality mills to counter what they saw as the stock companies' failure to discriminate properly among risks and give lower premium rates to the better ones. In hindsight, this seems logical; presumably, all the first company needed in order to succeed was wise and determined management, which luckily, according to a company history, it had.

¹³ Zachariah Allen wrote in 1849, "It was in consequence of the advance of premiums by these (stock fire insurance) offices that this new institution for insurance was established." (In Dane Yorke, Able Men, p. 233.)

¹⁴ See cotton mill rate schedule from the 1860s reproduced in Dane Yorke, Able Men, p. 121. The idea of setting a base rate and varying it up and down according to certain individual characteristics of a building, was called "schedule rating." It evolved from the practices of the AFM companies and began to be used in the 1890s.

¹⁵ Zachariah Allen, manuscript autobiography, no date, in the Zachariah Allen papers, Rhode Island Historical Society. He recalled the reply of the President of an insurance company, to whom he applied for a reduction in his premium rate, "I can not go about to see all the mills insured by me, and attend to my business at the office; and an average must be made. The good mills must pay for the poor."

But in fact, the fabled "first" AFM company, Manufacturers Mutual Fire Insurance Company of Providence, Rhode Island (MMFIC), was not the first company chartered to insure factories. Allen mentions in his autobiography that "there had been several mutual insurance companies established by manufacturers of New England," and goes on to say that all had failed.¹⁶ "One of the last of these" early companies was a Worcester-based company that he does not name, but was probably the Manufacturers Mutual Fire Insurance Company of Worcester, Massachusetts, which was incorporated in 1834.¹⁷ By 1836, its charter had been revised to permit it to insure all kinds of non-residential buildings; still, it eventually "suspended" operations.¹⁸ Before it did, it proposed to turn over its business to a company Allen was establishing under the same name in Providence.

There was no model for this kind of company and no sure formula for success, however sound the idea might seem. Allen wrote that he felt the key to success for this kind of company would be a "more vigilant system" involving inspection of all risks and annual reinspection, something neither the stock companies nor mutual companies, which followed the practices of the stock companies, invariably conducted. MMFIC began operating in 1835 and stuck to its original mission of insuring factories; it was the model for all the later AFM companies. While it was successful from its inception in that its loss experience was low and members were able to realized savings in insurance costs, it had difficulty gaining the confidence of potential customers. Moreover, it had the factory mutual field to itself for thirteen years.

Some of the circumstances that allowed MMFIC eventually to flourish are entirely

¹⁶ Z. Allen, manuscript autobiography, RIHS.

¹⁷ Massachusetts laws, Chapter 34 of Acts of 1834.

¹⁸ The Manufacturers Mutual Fire Insurance Company of 1834 eventually was revived. In 1855, Mechanics Mutual Fire Insurance Company was chartered to insure houses, but in 1861 it merged with the inactive Manufacturers Mutual to become Worcester Manufacturers Mutual, a factory mutual company. (Information on the Worcester company from Charles Nutt, History of Worcester and Its People (New York: Lewis Historical Publishing Co., 1919), p. 1027, and D. Hamilton Hurd, History of Worcester County, Massachusetts (Philadelphia: J. W. Lewis & Co., 1889), pp. 1553-1554. Thanks to the Worcester Historical Museum Library for these references.)

historical. As the experience of the Worcester company shows, these conditions were necessary but not sufficient for success. The condition that probably triggered the founding of the companies was high premium rates. Base rates for textile mills varied by company and fluctuated over time, but during the 1830s - 1850s, rates never were less than 1 1/4 percent and more commonly were about 2 percent, but could be as much as 4 1/2 percent, per \$100 of indemnity, for damage from fire alone.¹⁹ Thus, insurance costs could be quite substantial and something an owner would be inclined to control if he could. The AFM companies had great success in reducing members' insurance expenses from the very start. For many years, the AFM companies simply set their rates at 75 per cent of the Aetna Insurance Company in Hartford's rate for industrial buildings, with variations according to the individual characteristics of a building.²⁰ While the final cost varied according to the expenses in any year, there was rarely a year when some portion of the members' already reduced-price premiums was not returned to them, making the effective premium rates very low indeed.

The second factor that contributed to the success of the companies was the close relationships among New England mill-men in the early industrial period, a situation that facilitated mutual action. Trust was important in the factory mutual companies since under Massachusetts law, at any rate, the insureds were responsible, up to a certain limit, for covering losses that exceeded income. Factory Mutual members had to trust that company officers were enforcing standards uniformly, inspecting risks carefully, setting premiums properly, and being thrifty. Officers presumably had to trust that members would be able to make good on their notes, if need be (this may never have been a concern actually for the

¹⁹ Information on rates from: Hawthorne Daniel, The Hartford of Hartford (New York: Random House, 1960), p. 90; The Factory Mutuals 1835-1935 (Providence: Manufacturers Mutual Fire Insurance Co., 1935); Dane Yorke, Able Men, p. 101. According to Atkinson, when MMFIC of Providence started, mill rates were 2 percent (Proceedings of the Society of the Arts at M.I.T., meeting 246, Jan. 8, 1880, p. 22.)

²⁰ The Factory Mutuals 1835-1935; Edward Atkinson, The Prevention of Loss by Fire, Fifty Years' Record of Factory Mutual Insurance (Boston: Damrell & Upham, 1900).

factory mutual companies, although it was in other mutual insurance companies).²¹ In New England, the AFM directors, executive officers, and members were business associates, neighbors, even relatives of one another.

A third factor was the emphasis of the AFM companies on preventing loss, which over time became as much an objective for the companies as indemnification, and distinguished them from stock fire insurance companies. Through the first three quarters of the nineteenth century, little technical information regarding structural fire protection was available for building owners, even from underwriters. As already noted, stock fire insurance companies did not always inspect the buildings they insured; this was especially the case for properties away from their home city, where customers were handled by independent agents.²² These insurance agents did not necessarily have training in underwriting, much less structural fire protection. MMFIC's policy of inspecting risks in fact helped win customers. As Allen recalled, from the very start, the inspections helped convince the insureds that fire precautions mattered -- all relevant information was "recorded on the books of the company" -- and encouraged them to make necessary improvements.²³ Since the AFM officers were knowledgeable mill-men and underwriters, the inspection visits may have been viewed by mill owners as a sort of safety consultation. In the last quarter of the century, the AFM advisory and technical assistance capacity increased and the companies began to offer a variety of technical services to members. Inspections became more frequent and were conducted by college-educated engineers rather than underwriters. The companies commissioned studies of construction methods and fire prevention, published pamphlets, prepared building plans at cost, and consulted on fire safety. These services were unique in the industry. When some

²¹ Stephen Kimball writes that members in mutuals with assessment types of policies sometimes would skip town before paying their assessment. (Insurance and Public Policy, p. 43.)

²² For example, when Continental Insurance expanded outside New York, risks were no longer inspected by company officers and the company relied on the judgment of agents, who were paid a 10 percent commission. (Ann Kelchburg with Ronald Mullins, A History of the Continental Insurance Company (The Continental Corp., 1979), p. 10.)

²³ Z. Allen, manuscript autobiography, RIHS.

of the stock companies began to offer similar services, in the latter 1880s, they were following the methods established by the AFM companies.

MMFIC slowly gained customers and in 1848, in another period of great cost pressures for textile manufacturers, a second mutual, Rhode Island Mutual Fire Insurance Company, was founded with the aid from the MMFIC.²⁴ This was the rather unusual way in which the mill mutual system grew: through an increase in the number of collaborating companies rather than through the growth of one or two companies. This particular strategy seems to have been the result of the preference of Zachariah Allen, who felt the system would be better off if the directors of each mutual were personally familiar with the properties they were insuring. Also, in this time before reinsurance, fire insurance companies invariably limited the size of policies they would write.²⁵ This practice meant that owners of a valuable properties, whether they insured with mutual or stock companies, had to take policies with several companies if they wanted to insure the full value. The maximum policy MMFIC would take per risk was only \$15,000. But with more cooperating mutual companies, the coverage of valuable properties could be shared while at the same time each one would limit its own exposure. As Allen explained his reasoning for encouraging the formation of a factory mutual company in Boston rather than expanding MMFIC,

My first impression was favorable to the enlargement of a single office to take \$30,000 risks, but on examining the subject I became satisfied that it is far better to enlist a double number of efficient inspectors of the mills, and to render available the personal knowledge of the risks, which a greater number of directors will combine.

(Between a Boston and the Rhode Island offices) a reciprocity of interests would necessarily establish a communication of intelligence ... such as now exists between the two mutual offices in this city, without the least danger of interruption by adverse interests, the common object being a reduction of insurance premiums to the actual cost on the best cotton mill establishments in New England, and thus a very excellent system of mutual insurance might be instituted, and of mutual surveillance to check carelessness for the common benefit.²⁶

²⁴ Dane Yorke, Able Men, p. 26.

²⁵ Hawthorne Daniel, The Hartford of Hartford, p. 165.

²⁶ Allen to James Read of Boston; letter reprinted in Dane Yorke, Able Men, pp. 233-234.

In 1850, the Boston Manufacturers Mutual Fire Insurance Company (BMMFIC) was chartered. Four more companies -- Arkwright, Firemen's, State, and Worcester -- started between 1854 and 1860. All were in New England as were nearly all the properties they insured, which consisted mainly, although not exclusively, of textile mills.

While they drew their customers from the same geographic area, the AFM companies did not compete with each other. Rather than pooling all their capital and becoming one large company, the capital was divided among companies. Each one limited the amount of coverage it would take on any single risk and thereby avoided being financially ruined by the destruction of one valuable property. The companies were not uniform in the maximum amount of insurance they would write on any property. BMMFIC wrote much larger lines than did the Providence companies; its policy was to set maximum amount of coverage per property according to total amount of premiums collected, rather than to set a fixed maximum per property like MMFIC. But even as the amount of coverage that could be taken by the companies increased, the value of mills and their contents also increased, and for many decades large mills were covered by a groups of companies, AFM and stock companies, each of which took pieces of the total coverage. As the number of mutual companies grew, factory owners could place a greater amount of the insurance they needed with the mutual companies and avoid placing part of their coverage with stock companies. While the stock companies gave Mutual members reduced premium rates, they did not give the Mutuals' rebates. During this period, relations between the mutuals and the stock companies were harmonious since the mutuals essentially were insurance brokers for stock companies.

While their practices were not uniform in every respect, because they wrote policies on the same mills, the AFM companies did adopt similar underwriting standards and requirements. This uniformity was informal at first. They did not collaborate directly to set standards until later in the century. In the early years, therefore, much of the work of the companies -- for example, each one sending its own representative out to inspect properties -- would seem to have been redundant. But Allen considered redundancy desirable. It was Edward Atkinson -- the scourge of waste and inefficiency -- who later in the century centralized certain functions and made practices more uniform.

Although the AFM companies were supposed to accept only the best mills, the

standards of the mutuals and the stock companies were little different in the formative years.²⁷ No great investment in the mill building was required to become a mutual member; the AFM companies excluded badly maintained (i.e., dirty) mills and insisted that mills have watchmen and some water on the property for firefighting. Since mills of all types were accepted in the early years -- even, for example, wooden mills -- as long as they were responsibly managed, the Mutuals probably had little influence on mill construction during this period.

The mills in Lowell, Massachusetts set the standard for first-class, fire-safe construction. The Lowell mills owners did not insure with the Factory Mutuals. In the early days, owners carried no insurance,²⁸ but in 1850 (in the same month that BMMFIC was chartered), they formed their own mutual insurance company. The fire protection methods adopted at Lowell, and the example set by Lowell's renown civil engineer James B. Francis (1815-1892), of approaching fire safety as an engineering problem, influenced the standards and practices of the Factory Mutuals.

Evolution of the AFM Standard Mill

The Lowell mill buildings were considered models of factory design in the early decades of the century and were copied by mill owners elsewhere. The extensive system of fire protection at Lowell that was in place by roughly mid-century provided a important source of ideas for mill owners and designers. How this system developed was recounted in 1865 by James Francis, Chief Engineer of the Proprietors of the Locks and Canals company in Lowell, which operated the water works that powered the mills.

Francis wrote that from the beginning, the mills at Lowell had equipment for fighting fires.²⁹ The earliest mills, built in 1823, had water cisterns on their roofs, which supplied

²⁷ Frederick Down, "History of Factory Fire Insurance," in John Brown, ed., Lamb's Textile Industries (Boston: James H. Lamb Co., 1911), p. 248.

²⁸ Actually, a mutual company -- the Lowell Mutual Fire Insurance Company -- was chartered in 1832, but from the statement of James Francis, the manufacturing corporations did not join. (Chapter 96, Massachusetts laws of 1832.)

²⁹ James B. Francis, "On the Means Adopted in the Factories at Lowell, Massachusetts, for Extinguishing Fire," JFI vol. 49, 3rd series (April 1865), pp. 268-275.

pipes and hydrants inside the buildings. Pumps kept these cisterns full. After a mill burned down in 1828, the mill-men realized the disadvantage of having water available only on the inside of a building and so water mains and hydrants also were put in the mill yards and connected to the pipes inside the buildings. At this point, the mills were independent of each other in their water resources and the water pressure in their pipes was maintained by gravity. A major improvement was made two decades later when the water pipes of the mills were connected and a reservoir was constructed to supply this pipe network. Water throughout the system could be brought to bear on any mill in case of fire. These waterworks predated the city of Lowell's own water system and were the private property of the mills.

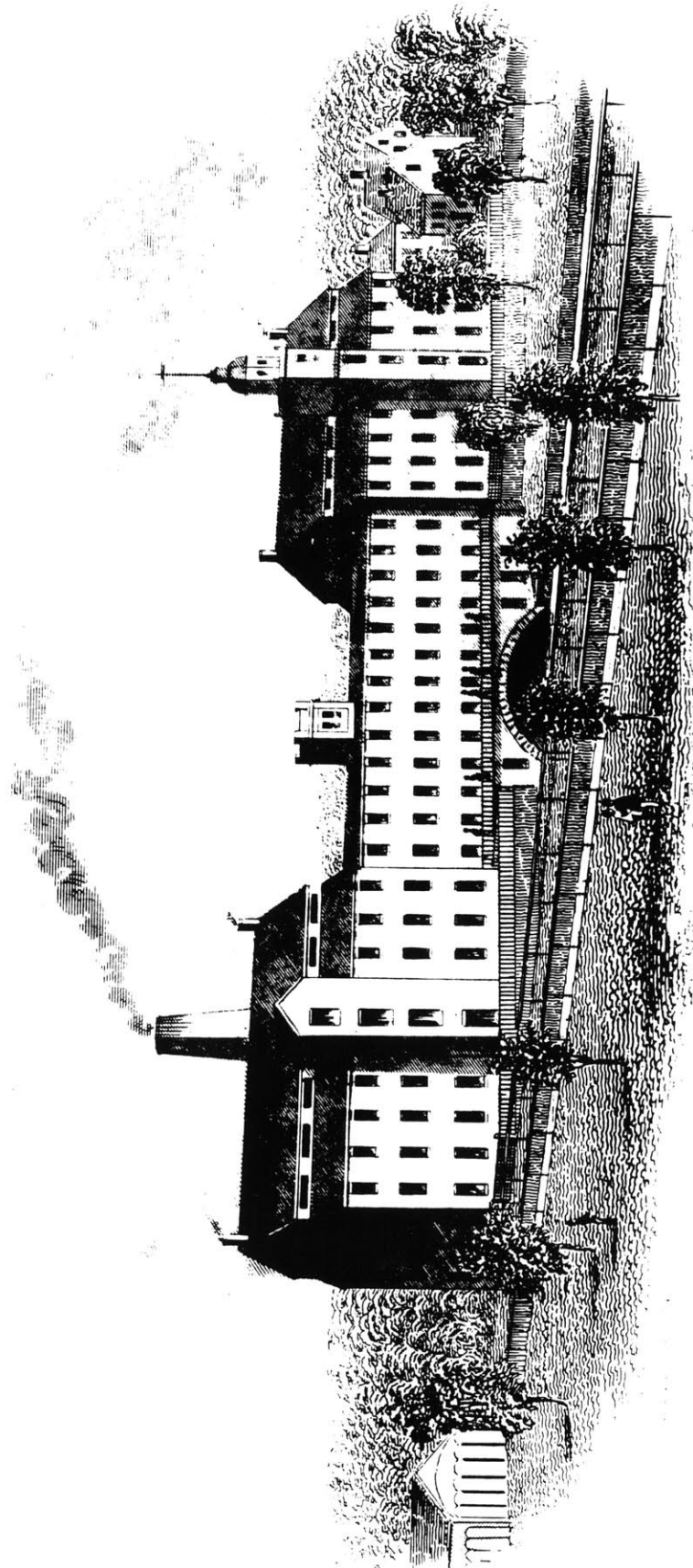
An additional precaution in the mills was sprinklers. At first, there were simply perforated, dry pipes attached to the water pipes inside a mill; water was let into the pipes by valves, which were turned by hand. This idea was borrowed from England where pipe sprinklers began to be patented in the early 19th century.³⁰ The first pipe sprinkler at Lowell was put in the picker room of the Suffolk Manufacturing Company by John Wright in 1845. In the early 1850s sprinklers were put under the roofs of Lowell mills. By the end of the decade, sprinklers were installed in all carding, picking, and spinning rooms, and other dangerous rooms and inaccessible spaces.

The mills also provided means of emergency egress and access. Platforms and ladders were built on the exteriors of the mills, which served both as means of escape and stations where firemen could fight a fire from outside a building. Protected egress was provided in separate stair towers, sometimes called "porches." (Illustration 5-2.) The practice of building external stair towers was an old one, dating from at least the second Boston Manufacturing Company Mill at Waltham, 1816-19.³¹ Undoubtedly, stairs were put in towers at first so as to leave the maximum amount of area inside the mill for machinery. However, the towers could be isolated from the mill floor with fireproof doors, so became a feature in a

³⁰ Charles Young, Fires, Fire Engines, and Fire Brigades (London: Lockwood & Co., 1866), p. 41 and 44.

³¹ Richard Candee, "Early New England Mill Towns of the Piscataqua River Valley," in John Garner, ed., The Company Town (New York: Oxford University Press, 1992), p. 121.

Illustration 5-2. Uxbridge, Massachusetts, mills with stair towers.



compartmentalization strategy. The porches also became the location for the building's water supply for firefighting, the standpipes (rising internal water pipes for firefighting) and hydrants. Iron shutters covered windows on walls that were within a certain range of other buildings at Lowell. Finally, twenty-four hour watching was standard there.

The Lowell Proprietors enforced uniformity in plant design and equipment -- including fire safety measures -- through terms in the conditions of sale of mill sites. So, for example, all buildings over ten feet built at Lowell after 1826 were obliged to have walls of brick or stone and a roof covered with slate or other noncombustible material.³² After the Lowell mill owners formed their own mutual insurance company, safety requirements were enforced through periodic inspections of members' properties.³³

Although it did not originate in Lowell, a characteristic feature of the Lowell mills was plank floors. While this type of floor, which first began to be installed in New England mills in the late 1820s,³⁴ has come to define slow-burning construction, it was not used at first for its fire resistance. Rather, it was adopted because it was a sturdy floor and because its underside made a smooth surface, which saved the owner from putting in a lath and plaster ceiling.³⁵ Plank floors were found in mills throughout New England at the end of the

³² "Proposals by the Proprietors of the Locks and Canals on the Merrimack River, for the Sale of the Mill Power and Land at Lowell," Boston, 1826. Baldwin Collection at M.I.T.

³³ In 1887, Lowell factories joined the AFM.

³⁴ Richard Candee dates the first appearance of this type of floor to the late 1820s and believes that the idea came from an article in the London Mechanics' Magazine (vol. 4, 1825, pp. 8-9), which was reprinted in American Mechanics Magazine. (Richard Candee, "The 1822 Allendale Mill and Slow-Burning Construction," Industrial Archeology vol. 15 no. 1 (1989), pp. 21-34.)

³⁵ As one contemporary explained, "The floors of the new mills [at Lowell] are to be made without joists, by laying plank on the girders and a flooring of boards upon them--this will present an even surface underneath which will be painted, and is intended to do away with plastering, which is continually shaking down and injuring the machines." Letter of Robert Israel to his uncle, Lewis Waln, August 9, 1831, Waln papers, Pennsylvania Historical Society. (Thanks to Steven Lubar for his transcription and to Bruce Laverty of the Philadelphia Athenaeum for identifying Lewis Waln.)

The London Mechanics' Magazine article cited by Candee (previous footnote) describes two kinds of floors used in mills in and around Manchester, England, one of which

1830s according to James Montgomery, an Englishman who wrote a book comparing American and British textile manufacturing practices.³⁶ He listed the plank floor as one of the main differences between U.S. and British mills and apparently did not know that this kind of floor also was built in England, although to a very limited extent.³⁷ He also noticed the fire fighting equipment, fire escapes, watch clocks for the watchmen, and remarked that British mill owners made no such provisions for fire safety.

While many of the ingredients of the slow-burning mill already were in regular use in New England by the 1850s, but they did not constitute a system. Underwriters and mill designers had their own notions of good construction practices, but these were not published anywhere. Rules began to be articulated in the latter half of the 1850s, following costly fires in mills insured by BMMFIC as well as the destruction of a mill at Lowell. In 1856, BMMFIC listed the features of a first-class cotton mill (one charged the lowest rate): stone or brick walls; slate, metal, or cement and shingle roof covering; standpipes and water pails; elevators walled off from the floors; fire escapes; steam heat; and (manual, at this time) sprinklers "wherever deemed to be necessary." The premium on such a mill was \$0.90 per \$100 of insurance and those not so constructed were charged one percent or more. Also in

is the iron and brick fireproof type, the other the plank floor. However, the plank floor is recommended for its sturdiness, not for its fire resistance. Further evidence that plank floors were not originally installed for fire safety is in a letter from a Englishman who wrote that he built a plank floor "about the year 1824" in his malt house, "this floor, though somewhat novel in its construction, was simply made for strength, and without any idea of its being less liable to be destroyed by fire than ordinary floors." (Reprinted in Scientific American Supplement vol. 4 no. 82 (July 28, 1877), p. 1297.) The fire resisting qualities of this floor were only recognized after the system was in wide use.

³⁶ James Montgomery, A Practical Detail of the Cotton Manufacture of the United States... (Glasgow: John Niven, 1840).

³⁷ The plank floor was described in The Engineer's and Mechanic's Encyclopaedia, published in London in 1836; it was described as "planks...about three inches thick, jointed and ploughed on the edges for the purpose of receiving slips of iron called tongues; this makes a tight and substantial floor, which, as well as the former, should be laid on iron joists." Such floors had been used in the Manchester area, according to the author, confirming the information in the 1825 magazine article. (Luke Hebert, The Engineer's and Mechanic's Encyclopaedia vol. 1 (London: Thomas Kelly, 1836), p. 526.)

this year, BMMFIC directors voted to discontinue insuring mills with wooden walls.³⁸

This was the first codification of what came to be the slow-burning system. It was advanced in the next decade under William B. Whiting (1817-1894). Whiting, whose background was in mill management, was hired in 1862 to assist the executive secretary of BMMFIC with inspections, and he began to keep records of the causes of fires in members' buildings. In 1865, after being appointed Secretary of the Board of BMMFIC, he wrote a report summarizing the previous year's loss experience. Whiting's report was made a part of BMMFIC's annual report, which was published and distributed to members. This was the first public disclosure of a fire insurance company's loss experience.³⁹ Whiting's reports became a regular part of BMMFIC's annual reports thereafter. Later, Edward Atkinson used Whiting's records to quantify fires and losses by cause, which helped guide standards and rate setting, and research into fire prevention. Whiting was credited by contemporaries with establishing higher standards and, as an inspector for Manufacturers Mutual in Providence and BMMFIC (and perhaps for other mutual companies as well, beginning in the 1860s), for promoting greater uniformity among the companies.⁴⁰

The year 1865 was a difficult one for the insurance industry. Insured losses during the war years had been remarkably low, but luck ran out at the end of the war, and the stock companies began to experience above-average losses. The stock companies' search for some way out of these "complications" was signaled by the formation of the National Board of Fire Underwriters of the U.S. in 1866 -- the first American trade association for the fire insurance industry⁴¹ -- for the purpose of establishing uniform rates and bringing predictability to this

³⁸ Dane Yorke, Able Men, pp. 235 and 83.

³⁹ Dane Yorke, Able Men, pp. 113-114. Whiting's dates of service are also in a memoir of Whiting, January 31, 1894, in EA letters, volume dated Jan. 1, 1894-May 26, 1894, MHS.

⁴⁰ According to Charles Woodbury, "the successful administration of the general policy of [the Factory Mutual] companies in the execution of measures tending to reduce destruction by encouraging better construction of mills, ... adequate fire apparatus, and cleanliness of operation, is largely due to Mr. William B. Whiting." (The Fire Protection of Mills; and Construction of Mill Floors (New York: John Wiley & Sons, 1882), 2nd ed., p. 102.)

⁴¹ A. L. Todd, A Spark Lighted at Portland; The Record of the National Board of Fire Underwriters (New York: McGraw-Hill Book Co., 1966).

volatile industry. But with the return of prosperity in 1870, companies went their own ways and ignored the rate recommendations. Turmoil quickly returned. Chicago burned down in 1871 and many fire insurance companies went bankrupt. The Boston fire of 1872 caused more problems.

The Mutuals too suffered large losses in the 1870s, when several valuable mills burned. This experience prompted the beginnings of more systematic collaboration among the Mutual companies. Officers of several companies met to adjust losses and to distribute circulars. In 1878, Whiting was put in charge of inspection for all the companies and the frequency of inspections was increased, to quarterly.⁴² Despite the serious fires and the changing of the guard that was to come, the AFM companies had been extremely successful. At this time, there were seventeen Factory Mutual companies.⁴³ In its 27 years of existence, the BMMFIC had returned two-thirds of premiums collected to members.⁴⁴

Nevertheless, a significant reshaping of the Mutuals began when Edward Atkinson was elected president of BMMFIC in 1878. Atkinson was an indefatigable reformer whose diverse causes were joined by the thread of a hatred of waste. He hated waste of human life and was a pacifist; waste of talent and was a feminist; and waste of material resources and was an economist. He preferred increasing welfare through the judicious and thrifty use of resources as then distributed rather than, for example, by expanding the pie or radically redistributing it. Fire insurance may seem an unpromising field for a visionary, but actually it was in perfect accord with his inclinations. For Atkinson, the objective of insurance became preventing loss; he wanted the Mutuals to control loss not simply by accepting preferred risks, but to eliminate preventable loss and reduce unpreventable loss to a minimum.

This goal was to be accomplished, within the AFM world, through technical assistance and financial incentives, and outside, through education. Accordingly, Atkinson began to publish pamphlets, circulars and reports, aimed both at the "practical mill men" who were

⁴² Edward Atkinson, The Prevention of Loss by Fire.

⁴³ The Factory Mutuals 1835-1935, chart p. 353.

⁴⁴ Dane Yorke, Able Men, p. 137.

AFM's members, as well as the public at large.⁴⁵ He was sure the public would see things his way, once he put all the facts before them. This characteristic faith and optimism is captured in a memoir printed in an insurance trade journal at the time of his death,

[Atkinson] resembled the type of New England old-time clergyman represented by the one in Mrs. Stowe's "Minister's Wooing," who felt irresistibly bound to "testify" as soon as he saw the light upon the moral side of a subject. Mrs. Stowe likened her personation to an "honest old granite boulder," impelled to roll with all its might toward any wrong thing, regardless of the consequences. Mr. Atkinson had a similarly uncompromising sturdiness of conviction.⁴⁶

As might be imagined from this description, Atkinson could be, and was, portrayed by many who disagreed with him as ridiculous and out of touch. That his opponents had to resort to character assassination is further evidence of his influence.

The Rise of the Loss Prevention Approach

The new direction for the Mutuals -- certainly, a new emphasis -- that emerged under Atkinson was putting loss prevention on par with underwriting. As early as March, 1880, Atkinson listed loss prevention as the "main purpose" of the AFM companies.⁴⁷ As he explained the objects of the companies in a later article, one whose title encapsulates Atkinson's theme ("Our Enormous Annual Loss by Fire; A Waste Born of Ignorance and Neglect"): "the main object of the work of the factory mutual underwriters is to prevent loss by fire; the secondary purpose being to pay indemnity for loss when it occurs."⁴⁸

BMMFIC's publication program, greatly expanded under Atkinson, was unusual in a number of ways. First, its circulars began to contain product recommendations, a sort of early Consumer Reports for the equipment and products used by BMMFIC's members. For example, the May, 1878, circular listed four types of watchman's lanterns that were

⁴⁵ Edward Atkinson, The Prevention of Loss by Fire, p. 26.

⁴⁶ The Chronicle vol. 81 (December 16, 1905), pp. 1698-1699.

⁴⁷ BMMFIC, Supplementary Report to January 1, 1880, March, 1880, p. 14.

⁴⁸ Edward Atkinson, "Our Enormous Annual Loss by Fire...", The Engineering Magazine vol. 7 no. 5 (August, 1894), pp. 603-612.

considered safe.⁴⁹ Secondly, the circulars contained reports on other kinds of research conducted especially for the Mutuals aimed at reducing loss. By 1887, the AFM companies voted to distribute the circulars.

What was unprecedented about this research was that it was experimental. Heretofore, actual fires were the main source of lessons. While the underwriters continued to learn from fires, Atkinson also wanted certain matters to be studied systematically. One of his first projects, in 1878, was to commission a study of machine lubricating oil, which his analysis of mill fires disclosed was involved in a great many of them. The study was undertaken by a member of the chemistry faculty at M.I.T. in an early instance of industry funded research.⁵⁰ At the same time, Atkinson added in-house expertise by hiring Charles J. H. Woodbury (1851-1916), an 1873 graduate of M.I.T. and the first college-educated engineer in the company, as an inspector and assistant for conducting technical research. In 1884, when BMMFIC moved its office to 31 Milk Street, the company set up a small area of experiments, which eventually expanded into a laboratory in the basement.⁵¹ In 1886, Atkinson hired a second college-educated engineer, John Ripley Freeman (1855-1932), a graduate of M.I.T.'s civil engineering course who later became an important spokesman on the loss prevention approach to insurance and the slow-burning system. Until the last decade of the nineteenth century, this laboratory was the only fire loss prevention research operation in the nation. The next year, in January, 1887, Atkinson centralized inspection, plan making, and research for the AFM companies; Whiting headed this Bureau of Inspections.⁵² Even as he increased AFM capacity of the Mutuals, Atkinson continued to commission studies from M.I.T. faculty and in 1902 established the Insurance Engineering Experiment Station, staffed by faculty, at M.I.T.

⁴⁹ The list of topics covered in the early circulars is recounted in Dane Yorke, Able Men, pp. 156-157.

⁵⁰ John Ordway, "Experiments on Lubricating Oils," Proceedings, New England Cotton Manufacturers Association (Oct. 30, 1878).

⁵¹ Dane Yorke, Able Men, p. 195.

⁵² Harold Williamson, Edward Atkinson, p. 107.

Woodbury and Freeman spread the gospel of the AFM to engineering students at Cornell and M.I.T. through lectures on mill construction. In the 1886-87 school year, Professors Gaetano Lanza (who studied the strength of wood beams and columns for BMMFIC) and Schwamb asked Woodbury to read a paper on the AFM fire protection efforts at M.I.T.⁵³ The following year (1888), Woodbury gave a lecture, "The Evolution of the Modern Mill," to students in Cornell's mechanical engineering department, a paper that, despite its title, focused on current practice rather than history.⁵⁴ While he noted that improvements developed over time and were the work of many men, and were kept to the lowest cost by relentless competition, he nevertheless credited the AFM underwriters with originating the system. It was these underwriters "who, finding it cheaper to prevent a fire than to settle a loss, have in every manner encouraged improvements in construction, equipment, and administration."⁵⁵ Freeman explained objectives of the companies to his engineering colleagues in 1889, "The companies are ... associations of leading manufacturers for mutual protection against fire, and the business of these companies is conducted on the theory that their organization is as much for the purpose of preventing or reducing loss by fire, as it is for the purpose of adjusting or distributing the loss when a fire does occur."⁵⁶ He also lectured at M.I.T. and Cornell, in 1894, on what was coming to be called insurance or fire protection engineering. He saw these lectures, to young men destined to take important positions in industry, as an effective way to spread the word on fire-resisting construction.⁵⁷

⁵³ "Reminiscences of Benj. G. Buttolph Covering his Apprenticeship in the Inspection Dept. from July 31, 1888 to Nov. 30, 1891," JRF papers, M.I.T. Archives.

⁵⁴ C. J. H. Woodbury, "The Evolution of the Modern Mill," Cornell University Non-Resident Lectures in Mechanical Engineering, printed in Scientific American Supplement no. 647 and no. 648 (1888), pp. 10329-10331 and 10346-10347.

⁵⁵ C. J. H. Woodbury, "The Evolution of the Modern Mill," p. 10329 and p. 10347.

⁵⁶ J. R. Freeman, "Experiments Relating to Hydraulics of Fire Streams," ASCE Transactions vol. 21 no. 426 (Nov., 1889), p. 307.

⁵⁷ JRF to Henry Evans, Vice President of Continental Insurance Co., May 5, 1894, JRF Papers, M.I.T. Archives, box 29, Fire Insurance Co.s Correspondence: 1894-1908.

Atkinson's trademark combination of technical information and fire safety advocacy first came together in a long report published in March, 1880.⁵⁸ As mentioned above, this was the report in which Atkinson stated that for AFM companies, loss prevention took precedence over indemnification. He presented figures on property destroyed by fire for the nation, taken from an insurance trade paper -- information intended to impress on the reader the magnitude of the fire problem. Then he listed construction methods that should be adopted and be avoided, and fire extinguishing equipment and so forth, all things that were required for AFM membership. This was probably the first public statement of AFM's rules for safe construction. While the report is apparently written for the information of potential members, it actually was aimed at a wider audience. Atkinson wished, first, to call attention to the faulty construction of ordinary buildings by contrasting them with mill construction standards. He also made a proposal for protecting "high buildings" in cities, buildings that the Mutuals would not cover, by fitting them with standpipes and hydrants on their roofs which would be controlled by the city's public fire department. The roof hydrants would enable firefighters to attack fires in upper floors more effectively than they could from the ground. Standpipes, although required in the Mutuals' mills, were rare in non-industrial buildings, although Atkinson noted that in Boston, the Post Office and Mutual Life Insurance Company building, at Milk and Pearl Streets, had standpipes.⁵⁹

For Atkinson, a key means of preventing loss was to raise the standard of construction, but still have the standard be cost effective. Where mutual officers had working definitions, arrived at empirically, of good practice, now Atkinson began to test practices and compile them. The standard continued to evolve, but through a more scientific process. The standards were incorporated in new construction and members also updated their existing buildings to conform to the evolving standards. By the last decade of the century, for instance, AFM companies began to urge companies to replace pitched or "factory" (i.e., double roofs) with shallow pitched, plank roofs. Many extant New England mills have an additional floor where the mill walls were extended up to what had been the attic and flat

⁵⁸ BMMFIC, Supplementary Report to January 1, 1880; Dane Yorke, p. 158.

⁵⁹ Supplementary Report to January 1, 1880, p. 18.

roofs.

But while the ingredients of the standard mill had been articulated by 1880, they were not available to the public in any detail. In his Special Reports No. 5, issued September, 1881,⁶⁰ and No. 10, dated April, 1882, Atkinson enumerated and expanded on the construction rules. In this same year (1882), the first textbook on slow-burning construction became available, Woodbury's The Fire Protection of Mills.⁶¹ The first part of the book concerned mill fire prevention and suppression, including suggestions for organizing a mill fire brigade and setting up mill yard waterworks, and would have been of interest only to mill owners and designers.

The second part concerned "safe construction of mills and storehouses," and was applicable to many kinds of buildings, not only mills. Some rules pertained to the permanence and stability of structures, but most were addressed to the issue of fire resistance. The ideal slow-burning mill described in Woodbury's text used ordinary materials in essentially traditional ways. Woodbury recommended plank floors, covered with mortar or sheathing paper; a flat plank roof, grooved and splined like the floors, covered with tin or gravel; wood columns (preferably) with cast iron caps; and floor beams fixed in cast iron wall plates. He wrote that mills should have internal water supply and recommended "automatic" sprinklers. These were systems of pipes like the old perforated pipe sprinklers, but with special little faucets, rather than holes, kept closed with solder that melted when the temperature in the room rose, releasing water. Woodbury also recommended electric lights, as a fire prevention measure.

Slow-burning construction, at this time, was not the rule even for mills in New England, let alone for mills outside the region. Not until the end of the 1880s, according to

⁶⁰ Date from Dane Yorke, Able Men, p. 184. I have not been able to see a copy of Report No. 5, which was simply entitled "Mill Construction."

⁶¹ C. J. H. Woodbury, The Fire Protection of Mills. The second edition came out within a year of the first (the usual size of a run was less than 1,000 books). The publisher John Wiley & Sons had begun to specialize in technical books by the 1870s. On the publisher, see John H. Moore, Wiley; One hundred and seventy five years of Publishing (New York: John Wiley & Sons, 1982).

the renown civil engineer John Ripley Freeman, then an inspector for AFM, was the slow-burning system beginning "to get a good foothold" among Philadelphia textile manufactures. It was rare outside of textile industry and in any sort of building west of the Hudson and in cities.⁶² But it was beginning to become more widely publicized and adopted.

The Slow-burning Idea Spreads Beyond the Manufacturing World

While slow-burning construction may have been little known outside of the New England mill world, the New England mill engineers were familiar with iron and brick fireproof construction and rejected it as impractical. Woodbury, for example, mentioned it in his textbook but considered it unsuited to mills, noting "floors made of brick arches sprung between I beams are so heavy and expensive as to be rarely feasible."⁶³ The objection was principally, but not only, the high cost: iron and brick mills were also inflexible. With such a large investment in a structure, a manufacturer might be reluctant to rearrange facilities in ways that were more advantageous, as they arose.⁶⁴ Woodbury also repeated the widely-held beliefs about cast iron columns: that iron columns heated in a fire could break if cold water was thrown on them, and that defects were difficult to detect. Interestingly, by this time, the iron and brick system was the standard for mills in Britain.

Atkinson, likewise, contrasted the system of construction he was urging with the "expensive and futile attempts at what is called fire-proof construction." He explained that his recommendations were for ordinary buildings, not for "post-offices, custom-houses, or other government buildings, nor ... such structures as have been erected by life-insurance companies," which were built without regard to cost. He argued that the solution to the fire problem was to make a greater proportion of all buildings safer by following his recommendations. A properly built wooden building "may be made as safe as the so-called

⁶² J. R. Freeman, "Comparison of English and American Types of Factory Construction."

⁶³ J. R. Freeman, "Comparison of English and American Types of Factory Construction," p. 137.

⁶⁴ C. H. H. Woodbury, "Methods of Reducing Fire Loss," p. 27.

fire-proof buildings of Europe."⁶⁵

Readers of American Architect and Building News (AABN), the first long-lived architecture periodical with a national circulation, were introduced to the slow-burning idea beginning in 1879, through editorial matter and correspondence. That this system -- heretofore used almost exclusively in New England and in mills, a kind of building rarely designed by architects -- should have received the attention it did is perhaps surprising, but again it is due to certain unique circumstances. First, many architects at this time were hungry for technical and structural information because they, and not engineers or other specialists, were responsible for the structural design of buildings. Papers about building materials, construction methods, and mechanical equipment for buildings were staples of professional meetings. AABN reprinted many such papers. Second, AABN was published in Boston, where BMMFIC was headquartered. Atkinson's company subscribed and he sent copies of BMMFIC's circulars and reports to AABN's editors, who often commented on them. Atkinson was a prominent local citizen and his views received respectful consideration, which no doubt encouraged him to keep writing to the editors. Through the pages of AABN, the principles of slow-burning construction received national exposure.

In 1879, AABN carried a long-running exchange between Atkinson and "C," a New York architect who was never identified. AABN set off the debate with a column in its "summary" section deploring the dreariness of New England factory towns. It blamed the AFM underwriters as much as the mill owners for this state of affairs, because "they have discouraged ... the employment of architects." Although dreary, the editor also noted that the mills were well designed from a fire safety standpoint: fires in mills insured by BMMFIC almost never were due to poor building design, such as defective flues or improper placement of heating pipes. He allowed that "unsatisfactory as the system is in its architectural results, it meets the demands for safe construction very successfully."⁶⁶

The editor was correct that the mill underwriters took a dim view of architects;

⁶⁵ All quotes from Edward Atkinson, "The Fire-Engineer, the Architect, and the Underwriter: Their Relations to Each Other," (Boston, 1880).

⁶⁶ AABN vol. 5 (April 26, 1879), pp. 129-130.

Atkinson considered architects, with few exceptions, to be masters of combustible construction.⁶⁷ In a reply to the editorial, he charged that when architects designed mills, they sacrificed safety and functionality for exterior effect. The fact that the buildings architects usually designed -- churches, hotels, schools, even the buildings constructed in downtown Boston after the 1872 fire -- essentially were firetraps, proved that architects lacked elementary knowledge of structural fire protection. Atkinson complained that AABN did not try to educate its readers; the latest issue, he observed, contained not a sentence about "the right construction of a building."⁶⁸ "C" answered this letter, arguing, in defense of architects, that they had both the knowledge and desire to design safer buildings. The blame for poor construction lay with the owners, who refused to build more substantially because of cost. He estimated that a fireproof building cost about 18 to 20 percent more than a common one and consequently, except for buildings with valuable contents or the mills insured by the Mutuels, it was "next to impossible to induce owners to expend money in extra protection."⁶⁹

In his response to this letter, Atkinson agreed that fireproof construction was too costly and explained that he was not suggesting that buildings be constructed absolutely fireproof,

Our mills are not fire-proof, but if kept clean and in good order they are slow-burning. The contents may burn with great rapidity, but the structures themselves are built with a view to slow combustion.⁷⁰

The great advantage of the system he was recommending over fireproof construction was that it was cheap. Atkinson gave examples of the defects he routinely found in "more finished buildings," the principal one being concealed spaces in the walls, ceilings, and roof. These spaces were created by the depth of the wood stud, joist, or rafter, which were finished with a

⁶⁷ He had no prejudice against the profession, per se. His son William became an architect.

⁶⁸ AABN vol. 5 (May 10, 1879), pp. 151-152; Atkinson was no more satisfied in this respect in 1888 (see AABN vol. 24 (October 13, 1888), pp. 174-175).

⁶⁹ AABN vol. 5 (May 24, 1879), p. 167.

⁷⁰ AABN vol. 5 (June 7, 1879), p. 182.

wall or ceiling of lath and plaster, forming "a network of hollow, wooden flues, connecting hollow walls with hollow ceilings, hollow ceilings with hollow roofs...."⁷¹ Should fire penetrate these cavities, it could spread both unseen and invulnerable to water. These spaces were not merely by-products of construction but were introduced by the designer or builder to provide temperature and sound insulation. But in Atkinson's opinion, they had to go, because they compromised safety.⁷² Likewise, any vertical space that might act like a flue -- a stairwell or elevator -- had to be separated from the floor of a building. He argued that the principles of slow-burning construction could easily and advantageously be applied to non-industrial buildings and should be applied to buildings the public could enter.

Still, since this system had almost never been applied to a non-industrial building, the question of how much more it would cost could not be answered conclusively. Atkinson thought the cost difference would be inconsequential. "C" disagreed and felt that architects would simply appear self-interested if they urged a more expensive system of construction, even this one, on their clients. "C" returned to a persistent theme among architects and building owners. He argued that stock insurance companies should adjust their rates to help owners pay for better construction, "Why cannot the insurance companies establish a system of inspections, and make rates varying ... according to the mode of construction?"⁷³ "C" also urged underwriters to lend their influence to enact general building laws, a way of compelling owners to invest in building improvements.

Peter B. Wight, one of the few men who could be called a fire protection authority in this period, learned of the slow-burning mill system through AABN and brought the system to the attention of stock underwriters at about this time. In a paper read to a meeting of the New York State Association of Supervising and Adjusting Insurance Agents in May, 1879 (reprinted in AABN), Wight distinguished between first class (noncombustible) and second

⁷¹ Edward Atkinson, "The Fire-Engineer..." p. 5.

⁷² Another way to prevent fire from spreading through these hollow spaces, while using traditional construction methods, was to introduce "fire stops," periodic noncombustible, horizontal barriers. This precaution came to be incorporated in building codes covering home construction.

⁷³ AABN vol. 6 (August 16, 1879), p. 56.

class "practically fire-proof" buildings. He mentioned slow-burning construction as an example of the second kind, characterizing it as a "heavy wood" system, required "by the mutual insurance companies of Massachusetts and Rhode Island." But while he hinted that fire suppression was an essential element of this system -- "all that is sought is the best facility for quenching a fire before it has had time to materially weaken the structure" -- he did not discuss the fire suppression equipment of mills or their applicability to commercial structures. He assumed that so much damage would be done to the frame of such a building in a fire that many parts would have to be replaced.⁷⁴

This debate raised many questions besides the one about the relative cost of slow-burning buildings. Did a mortar coating over wood -- a method used in some mills to shield wood from flames -- promote rot? Were the automatic sprinklers Atkinson recommended practical and reliable? What parts of the slow-burning system were essential and what were optional? Would the system shorn of the fire suppression features that were possible only in industrial plants, such as a dedicated water supply and the private fire brigades, give as good results?

At this time, Atkinson seemed unconcerned about these problems; he was convinced that the system was appropriate to many kinds of structures and only slightly more expensive than ordinary construction. Copies of circulars, plans, and general specifications were available free of charge, as part of what he called AFM's "missionary business."⁷⁵ But the questions persisted. The system began to be adopted but often inexpertly, to the detriment of the reputation of system and its most prominent advocate.

Slow-burning construction in non-industrial buildings

"Mr. Edward Atkinson's agitation in favor of the cheap but "slow-burning"

⁷⁴ AABN vol. 5 (June 7, 1879), p. 179.

⁷⁵ Edward Atkinson, Report No. 5, "Slow-burning or Mill Construction," Insurance Engineering Experiment Station, September, 1902. Circulars seem to have been free until 1902, at which time Atkinson began raising funds to establish a testing laboratory and endow a course in Insurance Engineering at M.I.T. He requested that FM members and others contribute to this purpose and began to issue reports to "subscribers" or for a small fee (25 cents for Report No. 5).

construction ... begins to bear fruit," noted one of AABN's editors in November, 1880.⁷⁶ The system was becoming more and more used in non-industrial buildings, notably warehouses, and it was also spreading to institutional buildings. According to Atkinson, already in 1878 -- even before BMMFIC's special reports and Woodbury's book -- three warehouses, one bank, one school, several churches, and one house in the Boston area were built according to slow-burning ideas.⁷⁷ While not identified, the school was probably the Chauncy Hall School, built in the mid-1870s, on which Atkinson said he was consulted.⁷⁸ The architect William G. Preston (1844-1910) built part of the Massachusetts Charitable Mechanics' Association building in Boston (1881) according to slow-burning principles, as he later recalled, "so far as the managers would consent to its use ... the system being less well-known then" Mill construction principles were incorporated in several other of Preston's buildings, including the Boston Terra-Cotta Company on Federal Street (1885), which was "of mill construction throughout," and Chadwick Lead Works on High Street (1887), both in Boston, and a library in the town of Lincoln.⁷⁹ A new building for M.I.T. in Boston, c. 1885, was constructed "substantially" after factory methods; a building at Cornell University, also constructed around this time, followed slow-burning principles; and a laboratory and boarding house at Woods Hole, Massachusetts was built according to specifications furnished by BMMFIC.⁸⁰ A new building of the Harvard Medical School was patterned on the "best type of American mill construction."⁸¹ An example of the application of mill construction methods to a hospital, which Atkinson frequently held up as a model, was one in Waltham,

⁷⁶ AABN vol. 8 (November 27, 1880). p. 253.

⁷⁷ AABN vol. 5 (June 6, 1879), p. 183.

⁷⁸ EA to Fire Marshall, City of Boston, March 2, 1894, EA letters, MHS, Jan. 1, 1894-May 26, 1894.

⁷⁹ Letter from W. G. Preston, AABN vol. 24 (Nov. 3, 1888), pp. 211-212, and AABN vol. 18 (July 4, 1885), pp. 6-7.

⁸⁰ Atkinson to W. H. Lincoln, Nov. 18, 1886, EA letters (Nov. 9, 1886-Feb. 26, 1887) MHS; letter from Atkinson, AABN vol. 24 (Nov. 17, 1888), p. 236.

⁸¹ J. R. Freeman, "Comparison of English and American Types of Factory Construction."

Massachusetts designed by his son William.⁸² Atkinson believed the Boston architecture firms Peabody and Stearns and Shepley, Coolidge, and Rutan to be "thoroughly familiar" with the principles of slow-burning construction.⁸³

While even advocates felt that the system was not well suited to homes, some attempts were made to adapt it. One was a summer house in Yarmouth, Maine (1889-90), with walls and floors made of planks. The owner found this house cost ten to fifteen percent more than an ordinary frame house. It was built by ship carpenters.⁸⁴ Another case was a house in Philadelphia, the construction of which was supervised by H. W. Brown, former President of the Philadelphia Mutual Fire Insurance Company.⁸⁵

Boston architects spread the system to cities outside the region. A group of investors in Philadelphia, of which H. W. Brown was one, engaged the Boston architecture firm of Cabot & Chandler, with Amos J. Boyden, to design a commercial building on slow-burning principles. The Brown Building on Walnut Street (c. 1882-83) was the result.⁸⁶ The floors of this building were protected with ceilings of mortar and wire cloth, as was done in the hazardous rooms of mills at the time.

The system was taken up by people outside of New England. It was publicized in Philadelphia by a local insurance leader and map publisher, Charles John Hexamer (1862-1921), through an article in the Journal of the Franklin Institute, which repeated much of the information in Woodbury's textbook. Following a deadly fire in the Leland Hotel in

⁸² EA mentions the hospital in several letters in 1894, for example. EA to Edgar Moore, Rutland Board of Trade, Feb. 13, 1894: William's hospital was "built on the lines we have developed.... It is the model hospital of the state." EA letters, MHS, volume Jan. 1, 1894-May 26, 1894. William also designed an annex to a science laboratory at Harvard, presumably also an example of the system. (EA to Edgar Moore, Feb. 13, 1894, letters, MHS, volume Jan. 1, 1894-May 26, 1894.)

⁸³ Harold Williamson, Edward Atkinson, p. 125, from a letter written in 1886.

⁸⁴ The house, at 74 Main Street, Yarmouth, was built for wood-pulp mill owner George W. Hammond. ("A Mill-Built Dwelling," AABN (Jan. 31, 1891), pp. 74-75; Frank A. Beard et al., Maine's Historic Places (Camden, ME: Down East Books, 1982), p. 345.)

⁸⁵ AABN vol. 24 (Nov. 17, 1888), p. 235.

⁸⁶ Charles Woodbury, ASME Transactions vol. 4 (Nov. 1882-June 1883), p. 401.

Syracuse, the magazine Architectural Era urged that "public buildings of all kinds ... be built on fire-proof or slow-burning principles."⁸⁷

For Anglophiles, London Fire Brigade's Captain Shaw's preferences for timber continued to be printed in AABN and reinforced the idea that heavy wood was a desirable material for fire-resistant construction. Shaw tested a twelve inch thick wood post and beams he removed from a burned warehouse, a post that had withstood fire and a deluge. He dried pieces, set them up, and set a fire under them, which burned for 2 1/2 hours. Afterwards he split the pieces and found that they contained enough uninjured wood to have continued to have performed as required.⁸⁸

The system began to be recognized and adopted in the western states, for factories and other kinds of buildings. Inland Architect announced that the architectural firm of Adler & Sullivan was designing a huge factory of the Aurora Watch Company in which "the eastern system of solid timber floors will be used."⁸⁹ In an 1885 speech to officials of mid-west insurance companies, Atkinson mentioned West's Hotel in Minneapolis as an example of a slow-burning building and said that Indiana had adopted the system for several hospitals for the mentally ill.⁹⁰ To illustrate a slow-burning type of floor, he mentioned Cupples Warehouse in St. Louis. Mill construction became popular in mid-West warehouse districts and was especially popular in St. Louis, where the local fire underwriting association gave reduced rates on buildings that complied with its slow-burning standards.⁹¹

⁸⁷ The Architectural Era vol. 4 (1890), p. 234.

⁸⁸ AABN vol. 29 (Aug. 16, 1890), pp. 104-105. The reason for this is that the charcoal that forms on the outside of wood pieces of very large size, like the posts and beams of mills, insulates the wood from oxygen in the air, which would assist with combustion.

⁸⁹ IA vol. 2 (August, 1883), p. 98.

⁹⁰ Edward Atkinson, "The Prevention of Loss by Fire and the System of Factory Mutual Insurance, an Address..." in Minneapolis, September 17, 1885, EA Papers, MHS. West's Hotel was not slow burning. Its floors were wood but between the joists was a filling of mortar and the floors were also protected underneath by a tile ceiling (from details published in Fireproof Magazine).

⁹¹ Leonard K. Eaton, Gateway Cities and Other Essays (Ames, IA: Iowa State University Press, 1989), p. 11; on insurance rates, quote from W. S. Eames, architect of St. Louis, in

At this time, too, owners and designers were experimenting with the new hollow tile products. They had a choice of systems: iron and hollow tile, tile-protected wood frame, or slow-burning. Slow-burning was preferred for ordinary sorts of buildings and for this reason had to be perfected, as the Boston architect William G. Preston explained,

"Fireproof" construction at the present prices of iron and terra-cotta is practically prohibitive in most cases, and we must develop as far as may be "slow-burning" methods.⁹²

The AFM methods for improving the safety of building -- setting standards, inspection, and education -- found their way into the practices of the stock fire insurance companies. Some stock companies began to give discounts when owners installed certain fire protection appliances, e.g., automatic fire alarms and automatic sprinklers.⁹³ In 1886, the stock fire insurance companies in Boston, through their trade association -- the Boston Board of Fire Underwriters -- issued a circular titled "Slowly Combustible Buildings."⁹⁴ Commenting on this report, the editors of *AABN* approved the writer's intentions but faulted the specifics. This brought a letter from the author, an inspector with the Board, who acknowledged that the circular could have been better written but defended it as a first attempt "to formulate the rules of 'Mill Construction,' now so universally insisted upon by all our great New England Mill Mutual Insurance Companies" and to which they owe their phenomenally low ratio of loss to premiums.⁹⁵ The writer noted that several warehouses in Boston were being completed according to the suggestions in his own circular.

By the mid-1880s, designers and underwriters were acquainted with the term slow-burning construction and at about this time, it began to reach a wider audience. It was mentioned in *The Forum*, in an article with the Atkinsonian title, "The Waste by Fire."⁹⁶

William Le Baron Jenney, "The Best Fireproof Construction for Buildings Occupied for Mercantile Purposes," *IA* vol. 30 (October, 1897), p. 24.

⁹² *AABN* vol. 24 (Nov. 3, 1888), p. 213.

⁹³ Clifford Thomson, "The Waste by Fire," *The Forum* vol. 2 (1886), p. 37.

⁹⁴ *AABN* vol 19 (April 24, 1886), p. 193 and vol. 19 (May 22, 1886), pp. 250-251.

⁹⁵ Letter of John E. Whitney, *AABN* vol. 19 (May 22, 1886), pp. 250-251.

⁹⁶ Clifford Thomson, "The Waste by Fire," pp. 27-39.

Charles Woodbury's lecture on the evolution of mill architecture, in which he discussed fire safety practices in mills, was published in Scientific American, and a paper covering the same topic was published in the first volume of Cassier's Magazine.⁹⁷

The most extended discussion of the system in a general interest magazine appeared in 1889, in an article by Atkinson for The Century Magazine titled simply "Slow-Burning Construction."⁹⁸ Atkinson made his detailed discussion of the evolution of the standard mill relevant to a general audience by introducing the system as one solution to the nation's serious fire problem. He calculated the "fire tax," "the heaviest tax imposed on the people of the United States;" it included the value of property lost to fire; the expenses and brokerage fees of fire insurance companies; and the cost of public fire departments.⁹⁹ Atkinson used this metaphor regularly, as did other writers in urging stricter fire protection measures. Also at this time, Atkinson was sending copies of BMMFIC pamphlets on slow-burning construction to heads of hospitals, asylums, and colleges which had suffered a fire.¹⁰⁰

Slow-burning construction had been discussed before a New York State group of stock fire insurance company officials in Syracuse, in an 1879 address by Peter Wight, mentioned above.¹⁰¹ It was urged in 1889 at a hearing on the proposed amendments to New York

⁹⁷ C. J. H. Woodbury, "The Evolution of the Modern Mill," Cornell University Non-Resident Lectures in Mechanical Engineering, Scientific American Supplement no. 647 and no. 648 (1888), pp. 10329-10331 and 10346-10347 and "Methods of Reducing Fire Loss," Cassier's Magazine vol. 1 (Nov. 1891-April, 1892), pp. 27-35 and 125-135. The second article was an update of one he read at the A.S.M.E. meeting, and published in their Transactions vol. 11 (1889-1890), pp. 271-310.

⁹⁸ Edward Atkinson, "Slow-Burning Construction," The Century Magazine vol. 37 (1889), pp. 566-579. Atkinson wrote a number of articles on economic topics for this magazine. Its editor, Richard W. Gilder, was recognized by the President of the A.I.A. in 1892 for his service to the cause of good architecture.

⁹⁹ Edward Atkinson, "The relation between the Architect and the Underwriter," Proceedings of the Society of Arts meeting 246, Jan. 8, 1880, p. 22. Atkinson had been calculating this tax since 1880, at least. Other writers used this concept as well, but as far as I can tell, Atkinson was the first to do so. See also Edward Atkinson, "Supplementary Report to January 1, 1880," BMMFIC, p. 15.

¹⁰⁰ AABN vol. 24 (October 13, 1888), p. 175.

¹⁰¹ AABN vol. 5 (June 7, 1879), p. 179.

City's building law as kind of construction the law should accept as a substitute for fireproof construction for buildings over 80 feet -- although it is unclear whether the mill system or semi-fireproof type was what the supporters of this proposal had in mind.¹⁰² At the same hearing, the president of the Continental Fire Insurance Company, Francis C. Moore (1842-1912) testified he would write policies on "slow-burning" structures at one-third less than the usual rate.¹⁰³ Moore described slow-burning construction in a pamphlet written about this time, Economical Fire-Resisting Construction, which opened with a summary of Captain Shaw's approving observations on the fire-resisting capacity of heavy timber construction.¹⁰⁴ He wrote that structural iron, if unprotected, was more dangerous than heavy wood construction. Moore was a leader in the movement to rationalize underwriting by establishing more meaningful categories for rating the construction and use of properties, and by basing rates on actual loss experience, rather than the crude categories and judgment then generally used. He led a group of insurance men who in 1893 published the first "schedule rating system," the Universal Mercantile Schedule.

Moore's endorsement of slow-burning construction undoubtedly encouraged owners to adopt it, and the trade associations of fire insurance companies in some cities followed Continental's lead and reduced rates for this kind of construction. At least two underwriters' associations, in Chicago and St. Louis, borrowed AFM's idea of a "standard" building.

¹⁰² William J. Fryer, Jr., who was active in seeking passage of amendments to the 1887 law, wrote that passage of a new law was held up because of a proposal allow an increase in height of non-fireproof buildings, if they were "constructed on what is termed the slow-burning principles of filling up or cutting off the air spaces between the wooden floor beams." ("The New York Building Law," Architectural Record vol. 1 (1891-92), p. 81.) This is more of a description of semi-fireproof construction, which was popular in New York, and not the mill system. So perhaps no real mill type buildings were built in New York.

¹⁰³ AABN vol. 26 (Dec. 28, 1889), p. 297. This hearing occurred apparently shortly after Boston's Thanksgiving Day fire, so Potter and Moore's confidence in the slow-burning system presumably was unshaken by the reports of the failure of the "slow-burning" Ames Building.

¹⁰⁴ F. C. Moore, Economical Fire-Resisting Construction, revised edition, May, 1892 (first published 1890). AABN, in its summary, notices the Moore publication and compares it with Atkinson and Woodbury's work. (AABN vol. 29 (Sept. 20, 1890), p. 173.) This is more evidence of the lack of information on the subject before the 1890s.

Beginning in about 1889, St. Louis' Board of Fire Underwriters reduced rates for buildings that complied with its specifications for "slow combustion" buildings.¹⁰⁵ Chicago's board, like Boston's Board of Fire Underwriters, issued a circular defining standard slow-burning construction for commercial buildings and also reduced rates for this kind of building.¹⁰⁶

Building codes, too, began to recognize slow-burning or mill construction as a fire resistant approach. It might be expected that in Boston, of all places, the building law would recognize slow-burning construction, but it did not, as such. Rather, it incorporated some of the fire resistance principles of the system. The law of 1885 -- by which time mill construction had become better known outside the mill world -- required that floors of new buildings within the fire limits "shall be deafened with plaster at least one inch thick, or two thicknesses of asbestos paper," or other approved material.¹⁰⁷ Boston's 1892 law recognized more elements of slow-burning construction. Fire stops were required in all non-fireproof buildings, except that new warehouses and stores 45 feet or more in height constructed with plank floors were exempted. The floors described in the code would have met slow-burning guidelines except that the plank could be two inches thick, while in mills, plank no thinner than three inches was used.

Presumably the code was sanctioning a kind of construction that was used in Boston. In addition, the pitch of roofs in non-fireproof buildings over sixty feet tall, if used for certain purposes, could not exceed 20 degrees, and very likely this was to create a roof that people could walk on, like mill roofs. Party and bearing walls could not be furred with wood but had to be plastered directly on the wall or on metal lath. The prohibition against wood lath was one of the strictest in slow-burning construction, although mill walls were not plastered. Finally, the ends of beams entering walls had to be bevelled so that they could roll out of their places without disturbing the wall, another feature of standard mill construction.¹⁰⁸

¹⁰⁵ William Le Baron Jenney, "Best Fireproof Construction...", " p. 23.

¹⁰⁶ Reprinted in IA vol. 20 (August, 1892), p. 5. On lower rates for slow-burning construction, AABN vol. 64 (May 13, 1899), p. 56.

¹⁰⁷ Massachusetts laws of 1885, chapter 374, section 102.

¹⁰⁸ Massachusetts laws of 1892, Chapter 419, sections 41, 58, 63, and 64.

By the 1890s, when some cities had imposed limitations on heights for non-fireproof buildings, extra height was allowed for slow-burning buildings. Chicago's building ordinance permitted mill construction for buildings up to 100 feet, while the limit for ordinary, non-fireproof construction was 60 feet. However, the definition of "mill construction" in the Chicago code bore little resemblance to AFM's standard.¹⁰⁹ Cleveland, San Francisco, and New Haven allowed buildings of mill construction to be built higher than ones of ordinary construction.¹¹⁰

Failure of Slow-burning Buildings

Whether because slow-burning buildings were somewhat more expensive than ordinary buildings, architects' indifference, or the unsuitability of the system to certain projects, use of the system was by no means widespread outside the manufacturing world in the early 1880s. Therefore, an architect ordinarily would have had limited experience with the system. At the same time, published materials about the system was scarce. For example, the editors of AABN, in answer to a reader's request for published material concerning "fire-proof business and office buildings," could only suggest papers by Peter Wight, Woodbury's book on mills, and a paper by Thomas M. Clark, which was only a survey of practice.¹¹¹ This was 1885. A year and a half later, AABN answered an inquiry for books on mill construction by naming Woodbury's book and a British publication that discussed British methods almost exclusively -- for example, systems of fireproof floor construction that were not used, and probably were not even available, in the U.S. -- and did not discuss slow-burning construction at all.¹¹² AABN's publisher arranged for a young technically-minded architect, Louis de Coppet Berg (1856-1913), to write a series of articles on "safe building," which were published serially

¹⁰⁹ Section of building ordinance quoted in William Le Baron Jenney, "The Best Fireproof Construction for Buildings Occupied for Mercantile Purposes," IA vol. 30 (October, 1897), p. 23.

¹¹⁰ Thomas Nolan, editor-in-chief, Frank Kidder's Architects' and Builders' Pocket-Book 16th edition (New York: John Wiley & Sons, 1916), p. 812.

¹¹¹ AABN vol. 17 (April 11, 1885), p. 179.

¹¹² AABN vol. 20 (Dec. 18, 1886), p. 294; B. H. Thwaite, Our Factories, Workshops and Warehouses (London: E. & F. N. Spon, 1882).

beginning in 1886; Berg did not treat mill construction. However, the lack of details concerning how to apply the principles to buildings other than mills, the system was being adopted.

The problems of adapting the system were not trivial. Take, for example, the problem of floor loads: warehouse floors were scaled for heavy loads, perhaps several hundred pounds per square foot, while the usual loads in textile mills were about 30 pounds per square foot and at most 60 pounds per square foot. The 1885 building laws of Boston and New York required that warehouse floors be constructed so as to bear 250 pounds per square foot. For such loads, a girder and beam floor (longitudinal girder and closely spaced beams, for a building on a narrow and deep city lot) provided the necessary strength at less cost than a mill floor.¹¹³

Although Atkinson's intentions in urging wider use of the system were good, the publicity the system received had the effect of over-selling it. Many of the city buildings "so-called" slow-burning would not have met his standards, yet they were known to the public as slow-burning. As slow-burning commercial buildings proliferated, the likelihood that one or another would burn and bring discredit to the system increased accordingly.

Such an event occurred in 1889, when Boston suffered its worst fire since the conflagration of 1872: the Thanksgiving Day fire on November 28, 1889, which burned a large part of the city's downtown. Several firemen were killed when the walls of burning buildings collapsed on them.¹¹⁴ This fire exposed -- or so it seemed -- the hazard of any but strictly fireproof buildings in a densely built up area. AABN noted that some of the buildings in the burned area supposedly had been designed with special attention to fire resistance, including H. H. Richardson's celebrated, and reputedly slow-burning, Ames Building.¹¹⁵ Supporters of improved construction worried that widely publicized failures of

¹¹³ AABN vol. 20 (November 27, 1886), pp. 258-259. Mill construction experts disapproved of this girder and beam framing system. See BMMFIC, Report No. 5, quoted in Thomas Nolan, editor-in-chief, The Architects' and Builders' Pocket-Book 16th ed., p. 763.

¹¹⁴ AABN vol. 26 (Dec. 14, 1889), p. 280. The fire started in a warehouse at Kingston and Bedford Streets called the Brown-Durrell Building.

¹¹⁵ AABN vol. 26 (Dec. 7, 1889), p. 261.

the slow-burning buildings would undermine efforts to strengthen building laws. Alarming headlines such as those in the regular papers -- "Fireproof Buildings Melt like Wax in the Flames," "Buildings Apparently Fire-proof as the Alps Completely Guttred" -- could discourage owners from improving their buildings. One AABN reader worried, "business men will quote to-days' newspaper accounts to prove the futility of erecting fire-proof structures."¹¹⁶ AABN replied to this letter saying that none of the buildings in the burned district was fireproof, therefore fireproof construction had not been tested and the public should not think it had been.

This practical test of slow-burning buildings prompted the editors of AABN to suggest that the system was not suitable for city building. This was not a reversal of opinion for the editors, who had always been ambivalent in their endorsement: slow-burning construction was an expedient until such time as laws would mandate more fire resistant construction.¹¹⁷ The Thanksgiving Day fire proved their reservations were warranted.

Atkinson responded to AABN's commentary by arguing that so far from being an "excellent example" of slow-burning construction, as AABN described it, the Ames Building was no example at all: the only thing this building had in common with a slow-burning factory was its plank floors. Otherwise, the unenclosed stairways; unprotected windows; lack of interior water service; lack of access to the building from the roof and rear; and the light framing in its pitched roof, "were utterly inconsistent with the very elementary conceptions of slow-burning construction."¹¹⁸ He went on to outline what a genuine slow-burning commercial building on a city lot would be like, and also claimed that such a building would cost no more than a combustible one.

But many observers -- supporters of safer construction methods and stricter building regulation -- had by now concluded that however perfect the slow-burning system might be

¹¹⁶ H. C. Burdett letter to AABN vol. 26 (Dec. 7, 1889), p. 272.

¹¹⁷ For example, AABN vol. 7 (Jan. 31, 1880), p. 33; AABN vol. 26 (Dec. 28, 1889), p. 297.

¹¹⁸ Atkinson, "Lessons From the Boston Fire," AABN vol. 26 (Dec. 21, 1889), pp. 293-295.

for the kind of fire danger that existed in cotton mills, it was not suitable for buildings in the congested districts of cities where the great fire danger was conflagration, i.e., fire communicated from one building to another.¹¹⁹ Atkinson often alluded to the exposure problem when explaining why BMMFIC could not insure mercantile buildings in crowded cities. Conflagration, in theory, was not a problem for the mills insured by AFM companies because, at this time, the companies only accepted risks that were separated from one another.

Mill fire protection methods, in fact, were designed to contain fires within buildings, not between buildings. Thus the system was suitable for certain kinds of fires -- fires that began in the contents of a building -- and protected the building from such fires. But a wooden building, especially if its windows were not well protected, was vulnerable to fires from the outside, which is the kind of fire owners of city buildings most feared. BMMFIC's own Charles Woodbury wrote that, because of the requirements for display and open floor plans, "slow-burning construction was not feasible for commercial buildings in cities."¹²⁰ Slow-burning principles might be applied with more success to certain kinds of buildings, such as ones that were well separated from others, like the schools, hospitals, and college buildings that Atkinson singled out as suitable candidates. But given the external as well as internal hazards in cities, experts began to view slow-burning and semi-fireproof systems as false economies.

This was certainly Peter Wight's view in 1893. He did not even include the slow-burning system in his overview of fireproof construction practice of American architects presented to an international gathering of architects at the World's Columbian Exposition. After describing two semi-fireproof style buildings, he warned "the words 'slow-burning' are not applicable to them, but refer only to building constructed with heavy floor-beams and thick plank floors, and not considered in this paper as fireproof in any sense." Wight explicitly distinguished slow-burning from semi-fireproof construction because the latter type

¹¹⁹ For example, John A. Fox, "'Mill construction' has steadily grown in favor, but it is somewhat difficult of adaptation to complicated structures, and is chiefly useful in buildings attacked by fire from within." (*AABN* vol. 26 (Dec. 14, 1889), pp. 281-282.

¹²⁰ *AABN* vol. 40 (April 8, 1893), p. 30.

was often described as "slow-burning."¹²¹ Atkinson and Wight were equally indignant at the misappropriation of the term -- Atkinson when the follies produced by "ignorant and incapable draftsmen" attempting to apply mill construction to mercantile buildings were called slow-burning,¹²² and Wight when the tile-protected buildings he considered practically fireproof were lumped together with wooden buildings!

Although slow-burning buildings were not merely a matter of floor material, it is difficult to know what other aspects of mill construction many "so-called" slow-burning buildings included. Buildings that lacked internal water for fire fighting and sprinklers, in which vertical and horizontal spaces were not isolated from one another, were not slow-burning in the AFM meaning.

In 1892, a series of articles critical of fireproof construction generally and especially slow-burning construction, its "bastard sister--a misnomer, by the way," appeared in a firefighter's magazine Fire and Water and were excerpted in an insurance trade magazine, The Spectator.¹²³ The real complaint in these articles was against very large, undivided floor areas, which firefighters universally opposed regardless of how a building was constructed. But the parts published in The Spectator focused on slow-burning construction, which in this context meant both the heavy timber and tile-protected types of construction, and suggested that this type of building, because it was so substantial, would burn longer and hotter than an ordinary building and thus was more dangerous. AABN mentioned these articles in a March number the following year, after another multi-building fire in Boston; once again, a building reported to be slow-burning was destroyed. AABN expressed the hope that the movement in Boston to limit floor areas of buildings with wooden floors would promote incombustible

¹²¹ This is how the term was defined in Chicago, as discussed in the previous chapter. See, e.g., the report of a fire in the partly "slow-burning" Lumber Exchange building in Minneapolis, IA vol. 18 (August, 1891), pp. 7-10.

¹²² E. Atkinson, "A Department of Insurance Engineering a Public Necessity," BMMFIC circular (March 1, 1902), p. 7.

¹²³ The Spectator vol. 49 (Dec. 2, 1892) pp. 296-97, (Dec. 29, 1892) p. 308, and vol. 50 (Jan. 5, 1893) p. 9.

construction.¹²⁴

Atkinson responded to AABN's editorial with a long letter in which he sought to correct the common understanding of slow-burning construction as a matter only of the floors, by detailing the ingredients of the New England mill system.¹²⁵ Unprotected wood, he explained, naturally would burn "*if not suitably protected*" and the protection Atkinson had in mind was not a noncombustible barrier, but a fire extinguishing system: automatic sprinklers, standpipes, pumps, and hydrants. Why build slow-burning even though noncombustible systems were available? Because "there are many classes of business that will not bear the heavy cost of a more strictly fireproof method of construction." He wrote that he knew of only one instance where a properly built mill floor had burned through,¹²⁶ and one where wood posts had given way before the other parts of a building were already destroyed. His letter, titled, "Mill-Construction: What It Is, What It Is Not," was reprinted periodically as an AFM circular.

But even if perfectly constructed, was the slow-burning system appropriate for buildings that, unlike AFM's risks, were not watched around the clock and lacked alert workers, trained to douse fires with buckets of water and to maintain and operate the mill's firefighting apparatus?¹²⁷ This neglect of an essential feature of slow-burning construction, the fire suppression systems, when mill methods were applied to commercial architecture, caused Fireproof Magazine to warn,

the building of mercantile structures and warehouses in a manner similar to cotton mills of the New England States, and leaving out all the excellent precautions for preventing fires which there prevail, has been a mistake from which modern architects

¹²⁴ AABN vol. 39 (March 18, 1893), p. 161.

¹²⁵ AABN vol. 40 (April 1, 1893), pp. 14-15. That mill construction was seen principally as a way of building floors, see for example the chapter on "Slow-Burning Construction" in the series "Office-Help for Architects," AABN vol. 44 (April 21, 1894), pp. 27-28.

¹²⁶ The event referred to was an 1891 mill fire. (AABN vol. 40 (April 1, 1893), p. 1.

¹²⁷ Edward Atkinson, Report No. 5, "Slow-Burning or Mill Construction," IEES (September, 1902). He wrote, "more fires (in mills) are extinguished by handy buckets kept full of water than by all other apparatus." Automatic sprinklers were the second most important means of extinguishing fires.

will someday be held severely accountable by their own clients.¹²⁸

Owners of city buildings were especially slow to adopt what the Mutuals by the 1890s considered an essential fire protection feature: automatic sprinklers. In an 1897 article on the best methods of constructing fireproof stores and warehouses, William Le Baron Jenney quoted W. S. Eames, a St. Louis architect, concerning the destruction of a "standard slow-combustion" warehouse in a recent fire: "the building was not equipped with automatic sprinklers, and to this defect is attributed the loss of the building and its contents."¹²⁹ Eames added automatic sprinklers to his own warehouse buildings, a feature not required by the Underwriters' Board. In his article, Jenney did not discuss whether sprinklers would make mill construction satisfactory but simply repeated the now familiar refrain that in a conflagration, mill construction provided fuel for the flames and therefore such buildings should receive no reduction in insurance rates. Destruction of slow-burning warehouses in Chicago reportedly prompted the Chicago Board of Underwriters to reconsider its favorable rates for mill construction.¹³⁰ But, again, sprinklers were not considered an essential feature of mill construction there, according to the city's building code and even underwriters' rules.

Some of the severest criticism of slow-burning construction began to come from among self-styled experts in the new field of insurance, or fire protection, engineering. The members of this field had varying backgrounds: architecture, civil engineering, manufacturing, insurance. By the 1890s, many began to feel that the days of expediency -- of accepting slow-burning construction as better than nothing -- had passed and the day for fireproof construction had arrived.

This was the philosophy of a technical magazine that began publication in 1902, Fireproof Magazine (FM). FM was a monthly and it contained practical articles on aspects of fireproof construction, descriptions of exemplary buildings, reports on fires, and editorial comment; it seemed to be aimed at architects. While the magazine itself could not have had

¹²⁸ Fireproof Magazine vol. 5 no. 4 (October, 1904), p. 6.

¹²⁹ W. L. B. Jenney, "The Best Fireproof Construction...", p. 24. The building was the Ely-Walker Company store.

¹³⁰ Quoting Exchange, AABN vol. 64 (May 13, 1899), p. 56.

a large circulation (it ceased publication in 1911), its contributors also wrote textbooks and for other periodicals, and were professionally active. Thus, the opinions they expressed in Fireproof became known to many more people than the readership of FM. The magazine favored steel and tile fireproof construction, was skeptical of reinforced concrete, and considered "slow-burning" to be nothing of the kind. Indeed, the editor in 1903, William Clendenin, was downright hostile to mill construction. On an editorial page with a collection of quips, which would be incomprehensible save to fire protection cognoscenti, he left no doubt as to his views on mill construction,

The denuding of our forests brings at least one consolation. There will be less mill construction.

The merit of mill construction is an imputed merit. Good authority won't put out a fire.

The wooden Indian of mill construction, with painted and expectant face, hand extended--palm up--is still at a *premium*--with underwriters.

East Pepperell, Mass., has on view some very interesting exhibits of what mill construction is *not*. What it *is*, is ruins, in East Pepperell.

A good hot fire will get through its work in a slow-burning mill construction building in about the same time as through ordinary construction. Next to combustion, the preference of timber construction inclines to dry rot.¹³¹

In short, no combustion could be slow enough for the fireproof building advocates, who also condemned timber because it was impermanent, destined to "rot and decay."

This Chicago-based magazine, without any writers drawn from the mill world, criticized Atkinson both indirectly and by name for his mischievous influence. "Good authority won't put out a fire:" trust the ideas of the mill mutual insurers at your peril. F. W. Fitzpatrick, an architect and fire protection expert, commented unfavorably on one of AFM's updates of Report No. 5 on slow-burning construction, at a time when Atkinson was trying to raise funds to establish an insurance engineering department at M.I.T. or, at least, a public laboratory for testing fireproofing materials.¹³² Atkinson, Fitzgerald wrote, was a has-been,

If he feels that his best days are not yet over, that he can still learn and be useful, why

¹³¹ Fireproof Magazine vol. 2 (March 1903), pp. 5-6.

¹³² E. Atkinson, "A Department of Insurance Engineering a Public Necessity."

does he not throw what influence he retains in the direction of really good construction? ... On the one side of the scale lay these considerations: public safety, real economy, safe investment, protection to life and limb, and permanency of construction; on the other side place these considerations: 85 percent dividends in the New England Mutual Association and the usual commission upon the sale of automatic sprinklers. Which side will Mr. Atkinson choose?¹³³

Atkinson was not entirely alone in his point of view, of course. For example, Peter McKeon, a fire prevention expert working in New York, sided with Atkinson in this debate. It was idle, McKeon wrote, to talk about prospective fireproof buildings when the already standing ones were the great danger. The challenge was to make them safer, and the ways to do that were through fire suppression appliances; careful watching and alarms; isolating stairways and elevators; protecting windows; and having fire drills: in short, preventing fires from getting out of control through a combination of retrofit and owner responsibility.¹³⁴

Neither Atkinson nor his colleagues were backward or unwilling to consider new methods. They simply believed it was pointless, not to mention inefficient, to recommend systems that were far more costly than alternatives. Laws that made buildings unnecessarily costly were wrong: money wasted on safe construction was still money wasted. As John Freeman explained the matter to engineering students,

many of the economists who grieve over [the destruction of property by fire] and many friends across the water who view the magnificent public fire departments of some of our American cities a monuments to the recklessness of our architecture, forget that it is not much worse to burn up a dollar than to bury it beyond circulation in an over-expensive incombustible structure.¹³⁵

In fact, it was because he wished to gain information about new, low cost new products that Atkinson helped establish the short-lived Insurance Engineering Experiment Station (IEES) at M.I.T. in 1902. Concrete, for example, seemed to hold much promise, but little was known at the time about how well it performed in a fire and under manufacturing conditions. There were no standards for making concrete (concrete is discussed more fully in

¹³³ Fireproof Magazine vol. 2 (February 1903), p. 29.

¹³⁴ Peter McKeon, Fire Prevention (New York: The Chief Publishing Co., 1912), preface.

¹³⁵ J. R. Freeman, "Fire Protection Engineering," lecture notes, J. R. F. papers, M.I.T. Archives, box 29.

the next chapter). Concrete buildings collapsed; floors covered with concrete disintegrated over time; concrete turned into powder in a blaze. Atkinson appealed for contributions for this testing laboratory and associated academic department (which would have been the nation's first devoted to fire protection engineering) in order to establish a facility for testing new products like concrete. Among the studies undertaken at the short-lived IEES were one of a fire-resistant roof made of corrugated steel and cement and one of a kind of reinforced concrete floor made by the Columbian Fireproofing Company.¹³⁶

Atkinson was still writing and trying to raise the money that M.I.T. demanded in order to establish the new department, right up to the end of his life in 1905. Peter Wight, also a long-time worker in the field of structural fire protection and for a time FM's editor, wrote a long obituary in which he criticized no longer. Atkinson, he wrote, was fire prevention's "most conspicuous prophet."¹³⁷

Meanwhile, buildings advertised as "slow-burning" burned. Fireproof magazine reported on a deadly fire in West's Hotel in Minneapolis in 1906, a building Atkinson had twenty years before listed as a good example of slow-burning construction.¹³⁸ Ten people died in the fire. This c. 1880 building was a semi-fireproof type; it lacked sprinklers and there was no water in the hotel standpipes. Even so, the fire was contained. The deaths were not attributable to the materials of construction but were due to the lack of a general alarms system and insufficient egress; the occupants died of suffocation. This kind of safety issue, where the threat to life came not from the destruction of the building in a fire but from the lack of means of escaping fire and smoke, was a growing one and came to a head early in the next century, as will be discussed in the next chapter.

The slow-burning system was still used for mills in the early twentieth century, but its use declined quickly. Once the right ingredients and method of making it were worked out in

¹³⁶ Insurance Engineering Experiment Station, Report No. 7, "Fire-Resistant Roofs for Foundries and Machine Shops," 1903 and Report No. 10, "Tests of Columbian Fireproof Floors," 1903.

¹³⁷ Fireproof Magazine vol. 8 (1906), pp. 11-15.

¹³⁸ Fireproof Magazine vol. 8 (1906), pp. 76-77 and 80. The fire occurred on Jan. 10, 1906.

the first decade of the century, reinforced concrete construction was rapidly adopted for industrial buildings. There were several reasons why concrete came to be preferred. Factory sites were becoming increasingly built-up and at the same time electricity and improved transportation released mills from water-power sites. Mills in now packed factory yards and urban locations were at increased the risk of exposure fires, making thoroughly noncombustible buildings more desirable. Also, a concrete building could be stiffer than a wood framed one, which was an advantage as machine speeds, and consequently vibration, increased. Concrete was found to be less susceptible to damage from the chemicals that were coming to be used to a greater extent in industry. Moreover, large dimension, well-seasoned timber beams from certain species of trees (i.e., yellow pine) were becoming increasingly expensive.¹³⁹ On outlying, cheap land, a manufacturer could build a one story plant. One story factories, which could be lighted by skylights, and warehouses became increasingly common in the twentieth century. All of these developments made the multi-story, wooden, slow-burning mill obsolete.

The 1916 edition of Kidder's Architects' and Builders' Pocket-Book had a chapter on "wooden mill" construction, adapted from BMMFIC's Report No. 5, in addition to one on reinforced concrete factory and mill construction. The author of the slow-burning chapter noted that for "so-called" fireproof types of construction, the cost "is, in many instances, no more than the cost of various types of mill construction."¹⁴⁰ In the revised edition of his important textbook, Fire Prevention and Fire Protection as Applied to Building Construction, Joseph K. Freitag retained the chapter on "Slow-Burning or Mill Construction." Nevertheless, he noted in his introduction that while this type of construction was acceptable in certain cases, it was "neither ideal nor equal to fire-resisting construction," and since the cost differential between the two was "fast disappearing," mill construction should soon be abandoned in favor of the "more efficient methods."¹⁴¹ The Mutuals discontinued

¹³⁹ A. P. Stradling in T. Nolan, ed., Architects' and Builders' Pocket-Book (16th), p. 772.

¹⁴⁰ A. P. Stradling in T. Nolan, ed., Architects' and Builders' Pocket-Book (16th), p. 758.

¹⁴¹ Joseph K. Freitag, Fire Prevention and Fire Protection (New York:John Wiley & Sons), 1921, 2nd revised edition, p. 2.

publishing Report No. 5 in 1925.¹⁴²

Legacy

Although wooden mill construction became obsolete, the system left an important legacy with respect to structural fire protection, beyond the mill world. The first was internal fire extinguishment system and especially automatic sprinklers. Such equipment was uncommon in ordinary building and was rarely part of the equipment of fireproof office buildings when it was almost universal in factories insured by mill mutual companies. Another detail of mill design that probably spread to the larger world of building through AFM publicity was a way of tying beams to walls that allowed the walls to remain standing if the interior was gutted.

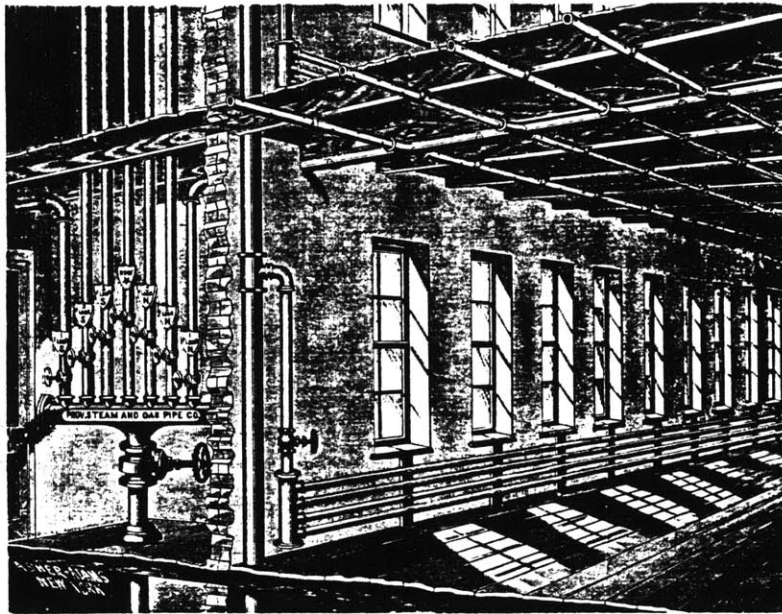
But more important than this structural and fire protection innovations was the contribution of the AFM companies to a new way of thinking about the function of fire insurance: as a service to assist owners in preventing loss as much as indemnifying them against loss. Atkinson demonstrated that insurance companies could do much to improve the quality of buildings and reduce fire loss, by developing and enforcing safety standards. He was no foe of government regulation of building construction, but he believed the market could do more than it was doing to improve the overall safety of the nation's building stock through financial incentives and cooperation. This idea was put into effect as the number of mutual fire insurance companies rose in the latter part of the century.

Automatic sprinklers

This now ubiquitous fire suppression appliance, required by law in most large cities to be installed in public buildings, was first used extensively in New England factories and perfected in factories before it was used in other kinds of buildings. Most mill fires began in the contents of a building -- in the machines, the stock, and so forth. The sprinklers, therefore, were designed to protect the building and its occupants from the burning contents, by dousing a fire in its early stages. One of the great advantages of sprinklers is that they could be added to existing buildings, and could installed without undue reconstruction or disruption to the occupants.

¹⁴² J. Crnkovich, "The New England Mutuals' Influence...."

Illustration 5-3. Section through a mill, showing control center for manual sprinklers.



Providence Steam and Gas Pipe Co., Providence, Rhode Island.

Perforated pipe sprinklers, supplied from a water tank on the roof, had been used in factories in New England since roughly the 1850s, but they had two principal drawbacks. First, human intervention was required to activate the system and second, they watered the areas along their length rather than concentrating water in the area that was burning. A solution to the second problem was to install separate pipes for each floor of a building, with each branch having its own valve. Such a system of pipes was manufactured by the Providence Steam and Gas Pipe Co., for one, and can be seen in the illustration of a c. 1876 sprinkler system. (Illustration 5-3.) The vertical pipes in the left hand side of the picture are labeled with the name of section of the building they serve. But this system did not solve the problem of manual operation. Moreover, the pipes did not work well: the holes became clogged and the system could not easily be tested.¹⁴³

Some sort of "automatic" system, to solve the human intervention problem, had long been sought. Several Rube Goldberg-like systems had been patented in England, with heat

¹⁴³ "History of Automatic Fire Extinguishing Systems," The Factory Mutuals 1835-1935.

recommended for ships as well as "churches, libraries, halls, museums, & c.," the idea was not adopted in England. Sprinklers were rare even in mills in England in the nineteenth century.¹⁴⁴ Because of concern over leakage and damage from water, English fire insurance companies actually charged higher rates for buildings with sprinklers.¹⁴⁵

The first commercially successful automatic sprinkler made in the U.S. was patented in 1874 by Henry Parmelee of New Haven. Parmelee patented two styles of head, but apparently the most successful one was a head covered with a cap held in place with solder, which came to be called the "sealed" or "water-joint" type head.¹⁴⁶ Except for the head, Parmelee's plan was like Stewart Harrison's, in that the pipes were kept under pressure and only the sprinkler head in the vicinity of a fire would open; the arrangement of pipes was also the same. AFM members began to adopt these sprinklers in 1875; the first to do so, significantly, were in Fall River, where a recent factory fire had killed workers who were trapped in the upper floor of a mill.¹⁴⁷ However, the response to the new sprinklers was not enthusiastic; owners distrusted automatic appliances.¹⁴⁸

In 1878, Parmelee arranged for Providence Steam and Gas Pipe Co. (PSGPC), manufacturers of the perforated pipe sprinklers, to manufacture and install sprinklers with his

¹⁴⁴ Charles J. H. Woodbury, "Automatic Sprinklers," Cassier's Magazine vol. 1 (Nov., 1891 - April, 1892), p. 263 and Charles Young, Fires, Fire Engines, and Fire Brigades (London: Lockwood & Co., 1866), p. 48. On the use of sprinklers in English factories, John R. Freeman, "Comparison of English and American Types of Factory Construction," and AABN vol. 79 (Jan. 10, 1903), p. 10.

¹⁴⁵ Charles J. H. Woodbury, "Methods of Reducing Fire Loss," p. 131.

¹⁴⁶ Patent no. 156,374, filed Sept. 30, 1874. Charles Woodbury, in his history of the development of the automatic sprinkler, describes Parmelee's 1878 sprinkler head as if it was the 1874 head. But Parmelee's first sprinkler patent, 154,076 (filed June 24, 1874), was for a sprinkler head that involved a spring.

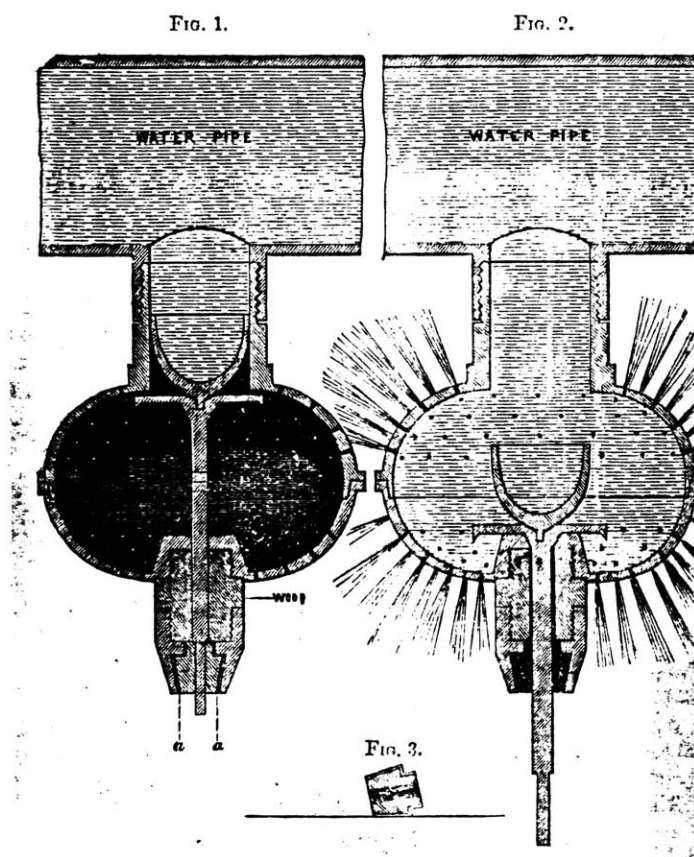
¹⁴⁷ This fire is discussed in the last chapter. Source for date, The Factory Mutuals 1835-1935, p. 241.

¹⁴⁸ Charles J. H. Woodbury, "Report on Automatic Sprinklers," Special Report No. 19, BMMFIC, May 15, 1884.

sensitive triggers that opened valves and released water into pipes. The first practical automatic device had the innovation of a "head" that fit into an opening in the sprinkler pipe; the valve was inside this sprinkler head and therefore the pipes could be kept filled with water. A rubber cap in the head stopped the water; it was held in place by a rod, which in turn was held up by a plug of solder at the bottom of the head. When the solder melted, the rod dropped, releasing the rubber seal, and water sprayed out of holes in the head.

(Illustration 5-4.) Besides automatic action and quick response (since the pipes were always filled with water), the head also had the advantage that it concentrated water on the burning area, since only the heads in the vicinity of a fire would open. An added feature of the system was an automatic alarm, set off by water moving through the pipes.

Illustration 5-4. Stewart Harrison's 1864-65 automatic sprinkler head, closed and open (right).



This system was developed in 1864-65 by an English firefighter, Stewart Harrison, but was not patented and was thoroughly described in publications at the time. Although it was

heads.¹⁴⁹ Also in this year, he patented a head similar to his simple cap type, but rather than having only perforations at the top, this head had a little turbine that spun when water entered the head and sprayed water from slits.¹⁵⁰

These heads worked well although they responded slowly because water, when it first entered the head, cooled the solder and kept the cap in place longer than was wanted. An improvement on this design was the "sensitive type" head, in which the soldered joint was separated from the water in the pipe. The first of this type was patented in 1879. In 1881, PSGPC's president, Frederick Grinnell, patented a "sensitive type," which also was designed to prevent leakage. Grinnell took out many patents during the 1880s. One of his ideas that became widely used was a splash plate: a bottle cap-shaped disk placed under the head that caused water to spray over a wider area.

The Factory Mutual companies favored sprinklers but did not require them in their members' main mill buildings. By 1880, less than a third of AFM members had sprinkler systems, manual or automatic, in their main mills, although sprinklers were universal in picker and drying rooms.¹⁵¹ Atkinson was a great believer in the value of sprinklers and began to advocate automatic sprinklers, even though PSGPC was the only company that made automatic sprinklers at the time.¹⁵² To encourage mills to install sprinklers, in 1881, Spinners Mutual Fire Insurance Co. was formed to insure risks fully protected with sprinklers. Atkinson was its president. The next year, BMMFIC voted to either drop or raise rates on risks that did not have sprinklers in all places deemed dangerous or inaccessible. As sprinkler protection became the rule for AFM risks, Spinners Mutual soon was discontinued.

However, the sprinklers in use were largely the manual kind; automatic sprinklers were not yet required. They were still more or less experimental devices. By 1882 only 30 fires in mills protected with automatic sprinklers had come to Atkinson's attention: 29 of

¹⁴⁹ "Highlights of Grinnell History," pamphlet in "Plumbing-Fire Protection" curator's files, Division of Engineering and Industry, National Museum of American History.

¹⁵⁰ Patent no. 205,672, filed Dec. 27, 1878.

¹⁵¹ Charles J. H. Woodbury, "Report on Automatic Sprinklers."

¹⁵² Harold Williamson, Edward Atkinson, p. 117.

these involved Parmelee sprinklers and one, a system manufactured by Burritt.¹⁵³

(Illustration 5-5.) Outside of AFM members and the Lowell mills, which still had their own mutual insurance company at the time, sprinklers were rare.

In the early 1880s, many companies began to manufacture automatic sprinkler systems. In order to recommend among them, in 1884, AFM, with assistance from the Boston Underwriters' Union, conducted a thorough test of sprinklers, even including existing heads removed from mills. In all, various models from ten companies were tested.¹⁵⁴ As well as testing them for fire extinguishing, they were examined from the standpoint of construction, reliability, liability to leak, distribution of water, and cost. These tests uncovered defects in the various heads that the manufacturers corrected.

One problem with the Grinnell sensitive heads was that the metal disk that stopped the water corroded over time and froze in place. In 1890, Grinnell introduced a head in which a glass button replaced the metal disk. While it was Grinnell's product, it used features invented by John R. Freeman and purchased from him by Grinnell.¹⁵⁵ This sprinkler head became the standard head for several decades and is the model for modern sprinkler heads. Another step forward was the introduction, at the turn of the century, of dry pipe sprinklers. In this system, pipes were filled with compressed air, which held back water. These were used in buildings where there was danger of pipes freezing.

Though the new heads improved on the old, the older models still were very effective in reducing losses. A comparison of the value of property damaged in fires in rooms equipped with automatic sprinklers and those without, between 1877 and 1891, showed that the average loss per fire in the former was only 7 percent of the latter.¹⁵⁶

In 1892, PSGPC merged with two other sprinkler companies to become General Fire Extinguishing Co.; its sprinkler was called the "Grinnell" sprinkler. General Fire "owned all

¹⁵³ BMMFIC, Special Report No. 10, Boston, Mass., April 1, 1882, p. 30.

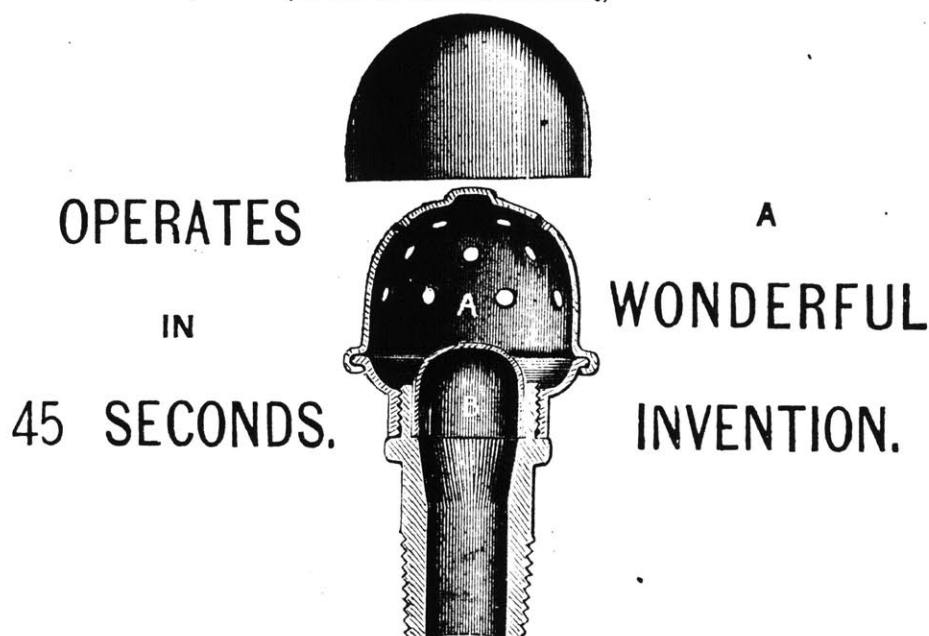
¹⁵⁴ Charles J. H. Woodbury, "Report on Automatic Sprinklers."

¹⁵⁵ The Factory Mutuals 1835-1935, p. 242.

¹⁵⁶ Charles Woodbury, "Automatic Sprinklers," p. 376.

Illustration 5-5. Burritt's automatic sprinkler head, c. 1882.

STILL AT THE HEAD!
BURRITT'S PAT. FIRE EXTINGUISHER.
(AUTOMATIC.)



THOUSANDS NOW IN USE.

The above cut represents the Fire Extinguisher $\frac{1}{2}$ size, and divided to show position of plug. The operation of our apparatus is absolutely certain, and a mill protected with it *cannot burn*. There is no "rat-trap" about it, its greatest point being simplicity. The heat of the fire *must* discharge the water over it. No Sediment can lie against and stop the perforations, no water lies against the fusible metal to harden it as in other apparatus.

A SILENT WATCHMAN.

We hold the patents on the best apparatus now manufactured.

OUR PRICES THE LOWEST! OUR WORK THE BEST!

→* UNPRECEDENTED SUCCESS. *←

We shall be glad to send our engineers to visit any Mill or Warehouse where absolute fire protection is desired.

We are also Proprietors of the "Hub" and "Standard" Extinguishers.

The A. BURRITT HARDWARE COMPANY,

WATERBURY, CONN., U. S. A.

FACTORIES and PRINCIPAL OFFICE: Waterbury, Conn. NEW YORK: 28 Platt St.

important underlying patents relating to automatic sprinklers and apparatus."¹⁵⁷ Even though Grinnell's company was the largest, and despite its dominance in patents, it was not the only sprinkler manufacturer; in 1894, ten companies made sprinkler heads that AFM approved.

Despite AFM's strong recommendation of sprinklers and actions to encourage owners to adopt them -- e.g., reducing premium rates on sprinklered mills and writing water leakage policies -- the spread of automatic sprinklers was slow in the 1880s and 1890s in the mill world. Not until 1910 did all properties covered by AFM have automatic sprinklers.

One reason owners were reluctant to adopt the automatic sprinklers, besides concern that they would work when needed, was that they feared damage from water as much as from fire. To protect against this, some Massachusetts mills took out water damage policies; they had to do this with stock insurance companies because in Massachusetts, mutual fire insurance companies could not provide this kind of coverage. Atkinson worked to change state law in this matter and succeeded in 1895, at which point BMMFIC began to offer a sprinkler leakage insurance policy. BMMFIC wrote separate leakage policies until 1902, when water damage was included in the fire insurance policy.¹⁵⁸

Water damage was not the only concern, of course. Sprinklers had their limitations and required care. Like any water pipes, wet pipe sprinkler systems could not be installed where they might freeze; they did not work well in buildings with very high ceilings or large open spaces; and they were ineffective against exposure fires.¹⁵⁹ Sprinkler heads did break open occasionally, and workers in a building had to be careful not to strike them. Moreover, mill-built structures were well adapted for sprinklers: their floors were water tight and they had traps built into the walls to drain off water. Other kinds of buildings did not have these

¹⁵⁷ U.S. Sprinkler Bulletin no. 44 (Dec. 30, 1905), p. 356.

¹⁵⁸ Harold Williamson, Edward Atkinson, pp. 119-120.

¹⁵⁹ C. J. H. Woodbury, "Automatic Sprinklers." John R. Freeman disputed the idea that sprinklers at great heights would be ineffective. Many building laws required theater stages to be equipped with sprinklers, and Freeman believed they would do good work. (John R. Freeman, On Safeguarding of Life in Theaters, address to the annual meeting of A.S.M.E., Dec. 4, 1905, reprinted from the Transactions of the Society, p. 34.)

features.

Nevertheless, automatic sprinklers seemed a good solution for buildings that, like mills, housed hazardous activities, and also for department stores, which had their own particular problems. Department stores, because of their large, uninterrupted floor areas, highly flammable contents, and high occupancy, seemed to very dangerous places to many fire experts. Although the stores were rarely fireproof, they were among the first non-industrial buildings to have private, firefighting equipment. For example, Lord and Taylor's store (1869-1873) at Broadway and 20th Street in New York, had interior standpipes and hydrants, like the mills.¹⁶⁰ While sprinklers of the 1880s and 1890s were not perfectly suited to high ceiling stores, they were preferable to the alternative, which was to break up the floor area of the building with fire walls. Two other kinds of buildings that were likely candidates for sprinklers, because they frequently burned and caused many deaths in the process, were theaters and hotels.

There are few hints in the many papers and discussions of fireproof construction that buildings other than factories had sprinklers in the pre-automatic sprinkler days. A Boston architect, writing in 1879 about theater design, recommended that the area over the stage be furnished with "a net-work of perforated pipes known as a 'factory sprinkler,'" the valve for which should be located near the prompter's box and be very conspicuous.¹⁶¹ Presumably this architect ordered sprinklers for buildings he designed. Already in 1877, a proposed law to regulate the construction of theaters drafted by New York architects called for stand-pipes to be installed in theaters, to be connected to "a thorough system of perforated pipes or sprinklers to be provided both on the stage and in the auditorium."¹⁶² Atkinson stated in 1880 that the Parmelee automatic sprinkler was "beginning to be introduced in some premises

¹⁶⁰ Comments of J. W. Ritch, Seventh Annual Convention of A.I.A., Proceedings, p. 44.

¹⁶¹ J.A.F., "American Dramatic Theatres," AABN vol. 6 (Sept. 6, 1879), p. 75. I am guessing that J.A.F. is John A. Fox, a Boston architect who designed several theaters.

¹⁶² "An Act, to provide for stability of construction and security against conflagration, panic, and other accident in theatres ..." AABN vol. 6 (Sept. 6, 1879), p. 77.

besides those insured in the mutual companies."¹⁶³ Whether he meant factories or other kinds of buildings is unclear. Grinnell believed that low insurance rates were hindering sales of his sprinklers.¹⁶⁴ And indeed the 1880s was a decade of low insurance rates, which may also explain the slow spread of the devices outside of factories. Another reason may be that sprinkler companies did not market their products well. At any rate, sprinkler manufacturers did not advertise in the principal national architectural magazine, *AABN*, in the 1880s. Also, in the 1870s at least, stock insurance companies did not give rate reductions for sprinklers.¹⁶⁵ Exactly when stock insurance companies began to recognize the value of sprinklers is unclear, but discounts for above average construction did not become the policy of underwriters until the invention of schedule rating in the early 1890s (discussed in Chapter 6).

Perhaps the first non-industrial buildings to have sprinklers were those with which mill-men had some connection. For example, Grinnell's automatic sprinkler was installed in the basement of one of M.I.T.'s buildings in Boston following a fire. Automatic sprinklers were put in a theater in Woonsocket, Rhode Island, at the suggestion of one of the theater's investors, who was familiar with them from the cotton mill he managed.¹⁶⁶

While the market, in the 1880s, was responding slowly to the availability of sprinklers, the law was stepping in to spread them. Theaters were the first buildings required to have sprinklers. Following the text of the proposed 1877 theater act, New York's new building law of 1885 required automatic sprinklers over and around the proscenium opening and on the ceiling over the stage (but not over the auditorium).¹⁶⁷ Likewise Boston's 1885 building law, which also contained many rules concerning theater construction, required

¹⁶³ Edward Atkinson, *The Fire-Engineer, the Architect, and the Underwriter...*, p. 20.

¹⁶⁴ Comments to Edward Atkinson's paper, "The relation between the Architect and the Underwriter," p. 30.

¹⁶⁵ *AABN* vol. 1 (Dec. 23, 1876), p. 411.

¹⁶⁶ John R. Freeman, *On Safeguarding of Life in Theaters*, p. 34.

¹⁶⁷ William J. Fryer, Jr., *Law Relating to Buildings, in the City of New York* (New York: The Record and Guide, 1885), p. 49.

perforated pipe over the proscenium opening and additional perforated pipes or automatic sprinklers "as the inspector shall direct."¹⁶⁸ By 1886, AABN, commenting favorable on Woodbury's report on sprinkler heads, stated that "all the new first-class theatres in this country, we believe without exception, are equipped with a full sprinkler service over the stage."¹⁶⁹ By 1892, automatic sprinklers in theaters had even helped extinguish a few fires.¹⁷⁰ In 1905, about 150 theaters in the U.S. had sprinklers.¹⁷¹

In the 1890s, insurance rates were high again, but stock insurance companies were also beginning to encourage sprinklers. In Cincinnati, lower insurance rates were given on buildings with roof tanks and automatic sprinklers.¹⁷² In 1896, the New England Insurance Exchange, an association of stock companies, approved the sprinklers of ten manufacturers.¹⁷³

Because of the history of the origin and development of sprinklers, through the AFM companies, New England had the most sprinklered buildings of any region in the early twentieth century. By one estimate, a third of the liability of all fire insurance companies located in New England was protected with sprinklers at that time. In Greater New York, by comparison, in 1905, only 605 sprinkler installations had been made.¹⁷⁴

Although New York building owners were reluctant to install them, the city's Board of Fire Underwriters became fans of sprinklers in the early twentieth century and urged their adoption. Joseph K. Freitag, in his textbook on fire prevention and fire protection, argued that fire protection must include sprinklers, since a noncombustible building alone could not protect the contents. "Efficient fire protection regard the contents of equal importance with

¹⁶⁸ Acts of 1885, chapter 374, section 137.

¹⁶⁹ AABN vol. 19 (March 27, 1886), p. 145.

¹⁷⁰ Edward Atkinson letter, AABN vol. 35 (Jan. 23, 1892), p. 62.

¹⁷¹ J. F. Freeman, On Safeguarding Life in Theaters, p. 37.

¹⁷² AABN vol. 33 (Aug. 15, 1891), p. 99.

¹⁷³ E. U. Crosby, Hand-book of the Underwriters' Bureau of New England, 1896.

¹⁷⁴ Joseph K. Freitag, Fire Prevention and Fire Protection (New York: John Wiley and Sons, 1921) 2nd edition, p. 869.

the surrounding building." Moreover, fire departments could not handle fires on the upper floors of high buildings. Several destructive fires in tall buildings proved the need for auxiliary protection.¹⁷⁵ And eventually sprinklers came to be required by law for a variety of commercial buildings. But the early development and spread of this important fire suppression device was largely due to the officials of the Factory Mutual companies.

A new method of tying beams

Falling walls had turned many building fires into conflagrations and also killed and injured firemen. It was in order to make sure walls would remain standing that building codes specified that they be extra thick. However, the codes also required that beams be tied or anchored securely to the walls, a provision that, depending on how the beams were anchored, defeated the objective of the thick walls. The usual anchoring methods involved tied a beam into the wall or bolting through the wall and thus the beams were liable to overturn the wall should the interior structure collapse in a fire. There were methods of anchoring that avoided this problem, such as supporting beams on corbel arches built out from the wall, but probably many designers neglected this detail.

Designers of slow-burning mills did not. The earliest statements of details of slow-burning construction, for example, Charles Woodbury's textbook, Fire Protection of Mills, recommended that beams not be bolted through the wall. Rather, beams were to be anchored this way: a cast iron plate with a rib along its top surface was built into the space in the wall where the beam was to rest; the beam had a groove on its lower side that fit over the rib. The top side of the beam, at the end that rested on the wall, was cut at an angle. The beam was secure horizontally, but could fall without disturbing the wall. (Illustration 5-6.)

A later refinement of this idea was the Goetz wall anchor box, patented by Mancel Mitchell and Henry A. Goetz, both of New Albany, Indiana in 1888.¹⁷⁶ The Goetz-Mitchell wall anchor system, as it was called, replaced the plate at the bottom of a beam opening with a cast iron box. Like the plate, the box had a rib on the inside of its bottom side, which held

¹⁷⁵ J. K. Freitag, Fire Prevention and Fire Protection, pp. 852-855.

¹⁷⁶ Patent no. 387,004 (Jan. 19, 1888). The final style of the box included a lug from Goetz' patent 386,976, filed Jan. 27, 1888.

Illustration 5-6. Goetz box, wall anchor for wooden beams.

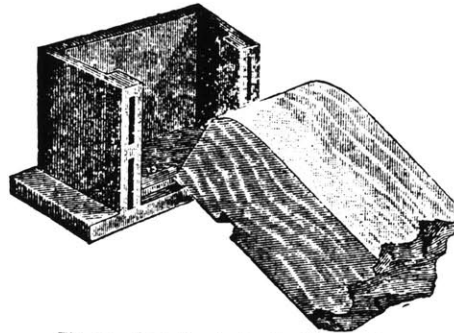


Fig. 46. Goetz Box Anchor for Wooden Girders

the notched beam in place. The box was built into the wall and beams slid into the box.¹⁷⁷ The boxes were made in various sizes to accommodate timber of different dimension.

Goetz' wall anchoring system was accepted for mill construction by the Factory Mutuals and promoted by Atkinson through the AFM circulars. Woodbury described the box in an article on slow-burning construction in Cassier's Magazine in 1892 as "preferable" to the iron plate.¹⁷⁸ By this time, the Chicago Fire Underwriters' Association was recommending this anchoring system in their specifications for standard "slow-combustion" commercial buildings.¹⁷⁹ Boston's building law of 1892 required that beams be "so shaped or arranged that in case of fire they may fall without injury to the wall." Unfortunately, the also law continued to require that beams be strapped to the walls with iron, which contradicted the objective of the wall box tie.¹⁸⁰

The use of the box would have declined along with wood and masonry construction. Nevertheless, in recommending this anchoring system, AFM officials helped bring greater

¹⁷⁷ "Methods of Anchoring and Safe Construction," IA vol. 14 (August, 1889), pp. 8-10. System also described in The Brickbuilder vol. 1 (Jan. 1892).

¹⁷⁸ C. J. H. Woodbury, "Methods of Reducing the Fire Loss," p. 29.

¹⁷⁹ IA vol. 20 (August, 1892), p. 5.

¹⁸⁰ Massachusetts Acts of 1892, chapter 419, sections 58 and 59.

attention to the problem of preserving walls in a fire.

Spread of mutual insurance and the loss prevention approach

The AFM approach was put into effect as the number of mutual fire insurance companies rose in the latter part of the century. The remarkable success of the AFM had the effect of spreading the mutual system outside New England. The stock companies in Boston and Philadelphia established a system of inspection and, according to Edward Atkinson, "have engaged two of our best men to set the work going."¹⁸¹ Philadelphia Manufacturers' Mutual Fire Insurance Company formed in 1880; later the Western Manufacturers Mutual in Chicago, Central Manufacturers Mutual in Ohio, and Manufacturers and Merchants, in Rockford, Illinois, were established.¹⁸²

As Atkinson regularly said, the AFM companies could insure only factories and associated buildings, and then only free-standing factories, in their own mill yard with their own independent supplies of water. Nevertheless, there was no reason why other kinds of building, for example, colleges and other suitable classes of risks, could not form their own mutual systems. He proposed such a system for city commercial buildings in 1883, "A Protective Fire Insurance Company," as a way to get the owners to install private water works -- standpipes and roof hydrants -- such as he had been advocating since 1880.¹⁸³ Considering the advantages, one may well ask whether the AFM model was copied. In fact, specialized mutual companies did start up in the last two decades of the century, at least -- another period of rising insurance rates. Town mutual companies had a long history; in the 1880s and 1890s, towns in the mid-West formed their own mutual fire companies -- not a good idea, considering that a conflagration could wipe out a town and its insurance system, and not what Atkinson had in mind.¹⁸⁴ But special mutual fire companies also started up.

¹⁸¹ Edward Atkinson, "The Prevention of Loss by Fire...an Address..," p. 17.

¹⁸² The Factory Mutuals 1835-1935.

¹⁸³ Edward Atkinson, "The Protection of City Warehouses from Loss by Fire," (February 1, 1883), EA Papers, MHS.

¹⁸⁴ H. Roger Grant, Insurance Reform: Consumer Action in the Progressive Era (Ames, Iowa:State University Press, 1979), chapter 4.

Wisconsin's mutual insurance statute authorized a variety of special mutual companies, and church mutuals were especially popular.¹⁸⁵ New England remained the center of mutual fire insurance -- the home of a disproportionate number of mutual companies.¹⁸⁶ How much these other mutual companies enforced loss prevention, rather than taking the traditional preferred risk route, I do not know.

The stock insurance industry was slow to embrace the loss prevention approach, a key aspect of which was to reduce rates on good risks. There were, of course, many practical problems in setting rates -- in correctly judging the value of any improvement, especially considering the exposure hazard of city buildings. Also, the brokerage system, which was the way stock company insurance was sold unlike the Mutuals, worked against practices that would reduce rates. Brokers might represent several companies, and they were paid a percentage of the value of the line they wrote. Obviously, they had no desire to see premium rates decline.

Nevertheless, the stock fire insurance companies sought to compete for "preferred risks," for which they could offer lower premium rates. In 1890, a group of stock companies organized their own version of specialized insurance pool for industrial properties, the Factory Insurance Association. It offered rates comparable to those of the AFM companies for similar classes of properties, or as Atkinson charged, at less than cost, in order to steal AFM's members.¹⁸⁷ (Eventually, the AFM companies devised a system of payments that was not like rates. Rather than collecting premiums and distributing dividends annually and holding notes for reserves, the AFM companies required permanent deposits, which

¹⁸⁵ H. Roger Grant, Insurance Reform, p. 96.

¹⁸⁶ In 1892, 75 of the 179 mutual companies in the U.S. with assets of \$15,000 or more were located in the six New England states, and they had together 34 percent of the total assets of such companies. ("Summary of Conditions and Business of American Mutual Fire Insurance Companies," The Spectator vol. 49 (July 7, 1892), p. 10.)

¹⁸⁷ Edward Atkinson to Henry Deyer, March 29, 1894, EA papers, letter book, Jan. 1, 1894-May 26, 1894, MHS.

constituted the companies' reserves and from which premiums were drawn.)¹⁸⁸ The first manager of the Factory Insurance Association was Francis W. Whiting, William Whiting's son.¹⁸⁹ Later in that decade, the stock companies founded their own fire protection engineering research laboratory, Underwriters Laboratories (UL). It was started by William Merrill, a M.I.T. graduate engineer, who probably was acquainted with the research work of the AFM.

Where sprinklers were installed, it was under the rules of AFM or the National Fire Protection Association (NFPA). The NFPA grew out of a desire on the part of underwriters to make their practices with respect to fire protection more uniform and the first matter addressed was standards for sprinkler installation. NFPA was a national organization, but its headquarters was in New England and its mission -- promoting prevention and protection, establishing standards, and education -- followed the approach developed by the AFM companies.

Atkinson lived to see the Baltimore conflagration of 1904, which had good news and bad news for slow-burning construction. The fire started in a warehouse reportedly of mill construction, which got out of control and led to the destruction of downtown Baltimore.¹⁹⁰ But after the fire, a writer for Engineering News noticed that although the non-fireproof buildings were totally destroyed, thick wooden telegraph and telephone poles on the streets survived. This, he wrote, showed "the value of the so-called 'slow-burning' mill construction."¹⁹¹

¹⁸⁸ Joseph F. Lee, Jr., The Functional Operations and Competitive Role of the Associated Factory Mutual Companies, PhD dissertation, University of Pennsylvania, 1965.

¹⁸⁹ Industrial Risk Insurers, The Hi-Spots (Feb., 1990), p. 3. IRI is the successor to FIA.

¹⁹⁰ Fireproof Magazine vol. 8 (1906), p. 90. This article also said that open stair and elevator shafts were the reason the fire spread so quickly. Communication between vertical and horizontal spaces was inconsistent with mill construction.

¹⁹¹ "Detailed Studies of Fireproof Buildings in the Baltimore Conflagration," EN vol. 51 no. 8 (Feb. 25, 1904), p. 171.

Chapter 6.**Triumph: the Fireproof Skyscraper, 1885-1910****Introduction**

After the great conflagrations in the first half of the 1870s, the rest of the decade was comparatively quiet. The Worth Street fire in New York's dry goods district in January, 1879 was one of few in which property worth millions of dollars was destroyed. The 1880s were remarkably conflagration-free as well, although enough individual buildings burned down to make the decade a comparatively unprofitable one for many stock fire insurance companies. Then at the end of the decade, in 1889, the nation's fire fortunes turned: Boston suffered its Thanksgiving Day fire and fires struck New York City, Seattle, Spokane, and Lynn, Massachusetts. By one estimate, just eleven fires in this year destroyed 30 million of dollars of property.¹

Although not in depression, as in the 1870s, the nation's economy was often down during the 1880s. But during the building construction upturns that punctuated the decade, a growing number of fireproof buildings were constructed. The principal sources for this increase were interrelated. One was a trend toward taller buildings, examples of which are the tall iron and brick, or, increasingly in the 1880s, iron and tile buildings, described in Chapter 4. The other was municipal building laws, enacted in the larger cities where tall buildings were likely to be constructed, which required that tall buildings be fireproof.

Building Codes Require Fireproof Construction

As improved passenger elevators became available in the 1880s, tall buildings began to crop up in cities around the country.² Elevators made greater heights economically feasible: in a walk-up building, rents declined with height, while in an elevator building, the

¹ Henry A. Goetz, in a paper to the National Association of Fire Engineers, quoted in *IA* vol. 16 (October, 1890), p. 31.

² On passenger elevators, see Anne Millbrooke, "Technological Systems Compete at Otis," in William Aspray, ed., *Technological Competitiveness* (New York: I.E.E.E., 1993), pp. 243-269.

upper floors fetched higher rents than did the lower ones (excepting the first two floors, which were still the most valuable).³ The tall buildings of the 1880s, of course, were not very tall by later standards -- ten stories, excluding towers, was about as high as they got. Nevertheless, it was to describe these very buildings that the term "skyscraper" was coined. The kinds of buildings that were built tall included hotels, apartment houses, stores, and, in New York at least, warehouse/factory buildings. However, the overwhelming majority of the tall buildings were office buildings.

Unlike the office buildings of the past, which were partly or entirely occupied by the owners, many of the new skyscraper office buildings were built entirely for rent. When an owner occupied a building, he had business records, stock, and employees at risk; in other words, he had property, besides the building, to protect. But the non-occupying, or speculative, owners had no interest in their buildings other than in the structures themselves and this interest could be covered by insurance. They consequently had less financial incentive than an occupying owner would to build in safeguards. There are some suggestions from contemporaries that tenants preferred renting offices in "fireproof" buildings and some owners advertised their buildings as "fireproof," presumably to attract tenants. But it is unknown whether owners of fireproof buildings could charge higher rents or profit in some other way (e.g., less turnover). At any rate, the average tenant could not know how well a building was constructed. The less expensive, semi-fireproof methods of construction might serve just as well to reassure the cautious tenants. And owners were under no compulsion to make their tall buildings even semi-fireproof.

The growing number of tall buildings in the early 1880s, although they were hardly common, began to alarm some people. They objected that skyscrapers blocked the light and air of their neighbors, contributed to traffic and pedestrian congestion, and inflated land prices in certain districts to the detriment of real estate elsewhere. Firemen and fire underwriters worried that a fire on the upper floors of a tall building could endanger a city. Indeed, a fire

³ William J. Fryer, Jr., "A Review of the Development of Structural Iron," A History of Real Estate, Building, and Architecture in New York City (New York: Arno Press, 1967) reprint of 1898, p. 464.

at over 80 feet, given ordinary water pressure and fire fighting equipment, could not be fought from the ground, and one at 60 feet could be fought only ineffectively.⁴ No fire ladders of the day could reach these heights. Consequently, some property owners, firemen, fire underwriters, and sanitarians began to urge that the height and volume of new buildings in already densely built-up areas be limited.

Height and volume limitations were the rule in European cities. In Continental cities, height limits served aesthetic as well as safety objectives, while in London, a city that many Americans looked to for guidance in building matters, building size limitations were justified explicitly on the grounds of fire safety. The building rules in London in 1890, for example, limited heights to 90 feet and volume to 450,000 cubic feet for a building no more than 60 feet tall.⁵ (A structure 75 by 100 feet, six stories tall, is 450,000 cubic feet.) It is unlikely that any American city limited the size of non-residential buildings before the 1880s or enforced any such limits. For example, Boston's post-conflagration building law of 1872 specified, almost as an afterthought following the rule requiring fireproof roofs on tall buildings, "But the total height of such buildings ... shall not exceed seventy-five feet."⁶ Despite this, buildings exceeding 75 feet were built in Boston, and neither this law nor even the thoroughly revised law of 1885 limited floor area.

Instead of restricting height, municipal building laws began to require that tall buildings be fireproof. Chicago's fire underwriters wanted the city to cap building height, but adopted a compromise resolution in 1883 that asked the city to require that buildings over 85 feet be fireproof and limited to office use.⁷ The next year Chicago enacted an ordinance

⁴ John A. Fox, paper read to the Boston Society of Architects, AABN vol. 26 (Dec. 14, 1889), p. 282. The limit given by the Committee on the Construction of Buildings of the National Board of Fire Underwriters in 1880 was about the same: 75 feet the highest for an effective stream. (Extracts of report printed in AABN vol. 8 (Aug. 28, 1880). p. 105.)

⁵ C. C. Knowles and P. H. Pitt, The History of Building Regulation in London 1189-1972 (London: Architectural Press, 1972), p. 89.

⁶ Massachusetts laws of 1872, chapter 371, section 20.

⁷ IA vol. 1 (Feb., 1883), p. 11.

requiring that buildings over 90 feet be absolutely fireproof.⁸ Other cities took a similar approach. For example, in Boston, the 1885 building law did not limit the height of non-residential buildings but required that, with the exception of churches and grain elevators, all new buildings exceeding 80 feet be "constructed throughout of incombustible materials, excepting interior finish."⁹ In the same year a new building law for New York City, one that had been long in the works, provided that future buildings exceeding 70 feet "shall be built fire-proof."¹⁰

While these laws of the mid-1880s were the first that required entire buildings to be fireproof, previous to this, parts of building under certain conditions were required to be fireproof. In Boston, as already mentioned, roofs of tall buildings had to be fireproof. New York's law of 1871 required that the first floor of tenement houses, over a street level shop or business, be constructed fireproof. Also, Mansard roofs in certain cases had to be fireproof and columns that supported walls above them had to be double (fireproof) columns.¹¹ New York's 1871 law was probably the only one in the U.S. that recognized fireproof construction as such, defining fireproof buildings as ones "where brick walls, with wrought-iron beams or cast or wrought-iron columns with wrought-iron beams, are used in the interior." However, no building at the time was required to be thoroughly fireproof.

The history of the passage of New York's 1885 law was recounted by William J. Fryer, Jr. (1842-1907), who helped write and lobby for a new building code. His story of the making of this law illustrates the positions of the interests most directly affected by it. Fryer, a manager of an architectural iron works, wrote that the 1885 law had its origins in the iron-

⁸ IA vol. 3 (April, 1884), p. 33. A few years later, IA reported that in December of 1886, Chicago's building law was amended to required that buildings over ninety feet be thoroughly noncombustible. (IA vol. 9 (April, 1887), p. 32.) I do not know exactly when the fireproof law took effect.

⁹ Massachusetts laws of 1885, chapter 374.

¹⁰ William J. Fryer, Jr., Law Relating to Buildings, in the City of New York, (New York: The Record and Guide, 1885), p. 33.

¹¹ William J. Fryer, Jr., Architectural Iron Work (New York: John Wiley & Sons, 1876), pp. 156, 158, and 163.

testing provisions of the 1871 law, which required that certain structural iron elements be "proved" -- in other words, tested to determine that they could carry the load they were supposed to carry -- before they could be used in a building. Moreover, the tests had to be done "under the direction and supervision of an inspector of the department of buildings;" each piece had to be marked with its safe load-bearing limit; and the inspector had the right to reject pieces.¹² While Fryer approved of such testing in principal, "the method of its enforcement at the start proved very obnoxious to the iron founders and was the first cause of the architectural iron manufacturers as an organized body, taking up the work of securing a proper building law."¹³

He does not explain exactly what was obnoxious about the implementation. The greatest problem with building laws, however, was not the specific requirements; it was enforcement, which was at best weak and at worst corrupt and incompetent. Cities were miserly in their support for inspection forces. In 1879, Chicago had four building inspectors, Boston had eight, and New York City, eighteen.¹⁴ Fryer was writing about a New York in the days of Boss Tweed. In the 1860s and early 1870s, the consent of the state Supreme Court was required for variances from the building rules, but this was no obstacle, according to Fryer,

The newspapers of the period teemed with articles showing how modifications were signed in blank by a Justice of the Supreme Court, and when filled out the sanctions so issued were sold for money by men who thoroughly understood the rules of addition, division, and silence.¹⁵

Seen in this light, New York's apparently comprehensive and strict building law of 1871 was not so much a progressive measure but a means for creating hurdles and therefore opportunities for bribery. Fryer alleged, for example, that allowable wall heights were set unreasonably low "in order to compel owners and builders to sue for favors from the

¹² William Fryer, Architectural Iron Work, p. 162.

¹³ William J. Fryer, Jr., History of Real Estate...in New York, p. 291.

¹⁴ AABN vol. 6 (Sept. 6, 1879), p. 73.

¹⁵ William J. Fryer, Jr., "The New York Building Law," Architectural Record vol. 1 (1891-1892), p. 71.

(Building) Department."¹⁶ Fryer, incidentally, was no disinterested good government type; his motivation was to reduce his company's vulnerability to arbitrary and dishonest authority.

New York's building law was amended several times between 1871 and 1885, but the changes mainly concerned the administration of the building department, not the technical requirements of the law. Possibly the depressed building situation in the 1870s made revision less urgent. But at the end of the decade, Fryer, representing the Society of Architectural Iron Manufacturers (S.A.I.M.), and others again began to agitate for a thorough overhaul of the law.

There are several factors that might account for the timing of this activity. Boston's 1879 fire had prompted a reexamination of the building law there and proposals for tightening the law. Another factor was the appointment of the well-regarded William Esterbrook to head New York's building department (which, for political reasons, had been made a bureau of the Fire Department); he replaced a very unpopular former head. Fryer's group and other building interests provided Esterbrook with a draft of a new building law. This became a bill, which was submitted to the legislature in 1881. It failed, was rewritten and reintroduced, and reintroduced again, until in 1885, "notwithstanding much opposition," a bill finally passed that was signed by the governor.¹⁷ Fryer does not discuss what may have been holding up passage. He mentions only one provision that caused controversy, which was that the shafts of new elevators be enclosed in brick walls, and in fact there was no requirement for this in the final law. (Boston's revised building law, enacted the same month as New York's, did require that elevators and hoists be in fireproof shafts.¹⁸)

New York's new law contained provisions that building interests sought, e.g., those restricting the discretion of building officials and creating a more responsive appeals body. In 1874, a Board of Examiners replaced the Supreme Court as the body that approved exceptions from the law granted by the building department, but it was not a court of appeals if an exception was refused. Under the 1885 law, the Board still approved variances granted by

¹⁶ William J. Fryer, Jr., "The New York Building Law," p. 77.

¹⁷ William Fryer, Jr., History of Real Estate ... in New York, p. 292

¹⁸ Acts of 1884, chapter 374, section 107.

the superintendent of buildings in cases of "practical difficulties" in applying the law, and in addition was authorized to grant exceptions in cases where "an equally good and desirable form of construction can be employed ... than that required" by the law.¹⁹ The purpose of this provision was to create a mechanism by which new construction materials and methods, not contemplated in the fairly detailed code, could be introduced. In addition, the Board was expanded to include representatives of S.A.I.M. and the Real Estate Owners and Builders' Association, who presumably would be sympathetic to owners. None other than William J. Fryer, Jr., became S.A.I.M.'s representative on the Board; he held this position until his death in 1907.²⁰

Architects and Tall Buildings

Another interest represented on New York's Board of Examiners was that of architects: a representative of the New York chapter of the American Institute of Architects (A.I.A.), the only national professional association, had been a member since 1874. Architects generally favored stricter building laws because the laws stood between their reputations and owners' desires to cut costs, even if safety was sacrificed. A.I.A. chapters helped draft and lobby for building laws in their communities and also served on appeals bodies.²¹ They were enthusiastic supporters of the fireproof construction requirements, although their attitude may not have been shared by all designers (A.I.A. members were a small minority of practicing architects).

In embracing fireproof construction, American architects were also embracing tall buildings. The attitude of American architects was more diverse than that of their British colleagues, who unanimously favored height limitations. While some American architects, too, opposed tall buildings, on the grounds of public health (light, ventilation) and safety, as well as aesthetics -- because the tall buildings overwhelmed the existing proportions of the

¹⁹ William J. Fryer, Jr., Law Relating to Buildings, in the City of New York (1885), pp. 53-54.

²⁰ Obituary, New York Times, June 5, 1907, p. 7.

²¹ The Boston Society of Architects drafted the original building law for Boston, which was enacted with few alterations, and a member of the B.S. A. was on the commission to draft the law of 1892. (AABN vol. 38 (Nov. 5, 1892), p. 79.)

city -- many others accepted tall buildings as a fact of business life. The remarks of the architectural writer Barr Ferree, addressing businessmen in 1892, are representative of the latter group,

The methods of modern business tend more and more to concentration, to the use of offices.... A small office ... is now all that is necessary for the transaction of a very large business. And where these can be conveniently had, provided with every modern necessity, as is the case with many large office-buildings in the great cities, tenants can be obtained without trouble, to the mutual advantage of all concerned, the city not less than the individual. If a city is to progress, rash is the man who would seek to stop its progress, and great his responsibility.²²

Indeed, tall buildings were the mechanism through which cities would become safer -- less prone to conflagration. Because the materials of the fireproof building were so costly that they practically had to be tall to be profitable, then the more tall buildings, the greater the fire resistance of a downtown. Tall buildings were as yet hardly enormous: few buildings higher than 16 stories were built in the entire decade of 1890s. So for many architects, the positive of fire resistance outweighed the negatives of high buildings.

A consequence of the increasing amount of fireproof work was that more architects became involved in designing fireproof buildings or sections of buildings required to be fireproof, and so a greater number became acquainted with the new technology. Once a limited group of designers -- those specializing in technically difficult projects -- were given commissions for fireproof buildings. As codes began to require that roofs and even tenement floors, in New York at any rate, be fireproof, many designers had occasions to use the materials of the fireproof building.

No special technical training was required at this time, however, for the competent and intelligent designer to design a fireproof building. Architects were guided in preparing structural designs by information in manufacturers' handbooks. The Pioneer hollow tile company published a catalogue in 1885 entitled "Fireproofing," which provided technical information concerning how to use their products.²³ Other fireproofing companies published

²² Barr Ferree, "Architectural Problems in Great Cities," AABN vol. 38 (Dec. 10, 1892), p. 164.

²³ Described in IA vol. 5 (July, 1885).

similar catalogues. Rolling mills' handbooks likewise were both catalogues and condensed textbooks, containing load tables and details of structural designs. These handbooks were heavily used by designers: they were more convenient than the few available building textbooks and also allowed an architect to plan a structure with products that were currently available from a mill. C. J. H. Woodbury, a mechanical engineer and authority on mill construction, believed the mill handbooks accomplished their intended purpose of expanding the use of rolled iron. He wrote in 1888 that the growth in the use of rolled iron was due in large part "to the excellent and reliable engineering information contained in the manuals and catalogues issued by the rolling mills."²⁴ The engineer C. W. Trowbridge advised his listeners at the Chicago Architectural Sketch Club in 1887 that when designing rivetted work, "the valuable hand book of the Dearborn Foundry Company gives perhaps the most complete data on the subject; this book should be in the hands of all draftsmen."²⁵ Paul Starrett, a prominent builder, recalled that when skeleton frames came in to use, draftsmen used the handbooks of the rolling mills to figure the sizes of steel members needed for a building, and this resulted in much "amateurish engineering."²⁶

Thus, after the mid-1880s, the course of development of the tall building and the fireproof building became entwined. But the laws were not merely ratifying the unavoidable: the buildings required to be fireproof at this time could have been built with wood floors, and even wood interior frames. After all, the threshold for fireproof construction was not especially lofty, encompassing buildings of seven, eight, or nine stories. In other words, the laws were consequential. They required owners to do what they did not have to do, and to spend more per square foot than they may have chosen to spend.

Very tall buildings, such as those that were built in the 1890s, after the fireproof laws were passed, as a practical matter, could not have been built with wooden frames, although

²⁴ Charles J. H. Woodbury, "The Evolution of the Modern Mill," Scientific American Supplement no. 648 (1888), p. 10347.

²⁵ C. W. Trowbridge, "Paper on Ironwork," IA vol. 9 (June, 1887), p. 77.

²⁶ Paul Starrett, Changing the Skyline: An Autobiography (New York: Whittlesey House, 1938), p. 37.

even they might have had wooden floors. (The load on a floor at the hundredth story is still essentially the same as what it is on the second, mainly the furniture and the occupants.) But even though the very tall buildings would have been built with noncombustible materials, they may not have been built well. The laws required fire safety measures -- for example, thick exterior walls and column fireproofing -- which were unnecessary for structural stability.

Between the tall buildings, and the other kinds of buildings that eventually were added to the list of buildings required to be fireproof, the building codes helped secure a market for fireproof building products and encouraged producers to enter this field.

The Invention of the Skeleton Frame

Fireproof construction historically had several disadvantages apart from high cost, perhaps the greatest being the weight of fireproof buildings. Much of the weight of the building was in the walls. Tall buildings, to comply with building codes, had to have very thick walls -- thicker than customarily built in the past, and thicker than absolutely necessary to support the loads. Thick walls were required for the sake of fire protection, in order to confine a fire burning inside a building, assure that the walls would remain standing should the interior be gutted, and protect the building from exposure fires.²⁷ (Falling walls had killed and injured many firemen.) The dimensions for walls, specified in the codes, varied with the height and use of a building, but except in low buildings, the walls taper as they ascend. The taller the building, the thicker the walls at the lower levels had to be. (Illustration 6-1.) Thick walls also consumed much space on the valuable lower floors, and the deep window recesses in these walls obstructed light. Heavy, load-bearing wall buildings were a particular problem for Chicago and also parts of lower Manhattan where the soil was compressible. In Chicago, the buildings actually sank.

At the turn of the 1890s, a new method of constructing high buildings evolved, which solved these problems. The new method was called "skeleton" or "skeleton frame" construction. Because the walls did not support floor loads or even themselves, they could be much thinner, which meant a great savings in weight and more natural light. Skeleton

²⁷ Thomas M. Clark, "Recent Improvements in Building," AABN vol. 16 (Nov. 15, 1884), p. 231.

Illustration 6-1. Wall thickness required in New York, 1885, for tallest category.

WAREHOUSE WALLS.

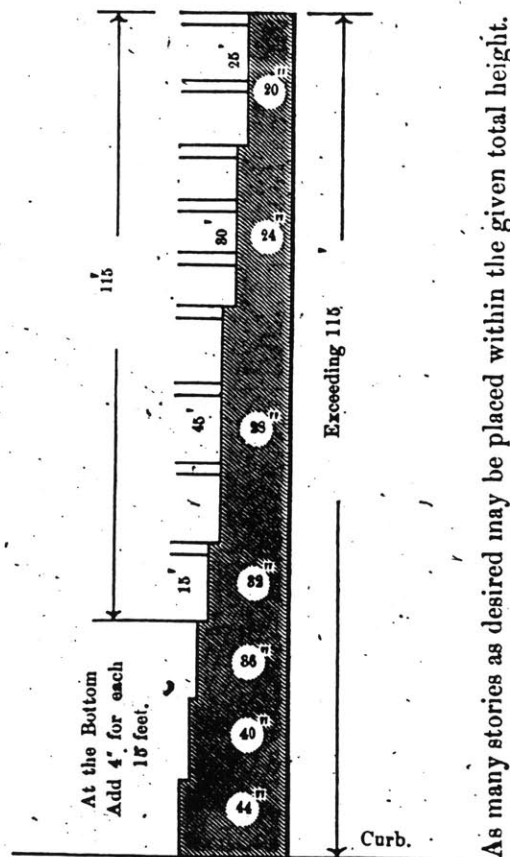
(For buildings other than Dwellings, except Churches, Theatres and Schoolhouses.)

Party and side walls have the same thickness.

Front and rear walls may be 4 inches less in thickness.

(If the building be more than 30 feet in width between walls, or more than 125 feet in depth, walls must be made thicker.)

(Fire-proof building.)

No. 14.

The intermediate heights can be varied, the various thicknesses being "to the tier of beams nearest" thereto.

construction was adopted enthusiastically: it revolutionized the way all buildings, not just tall ones, were constructed.

The system was the result of the continuous development of materials and methods of

constructing tall, heavy fireproof buildings in the 1870s and 1880s. By the end of the 1870s, the technological preconditions for creating a skeleton frame building, both the materials and the know how, were available. The materials included iron columns and beams; iron roof frames; and hollow, structural units for making floors, partitions, the inside face of walls, and roofs. "Know how" encompassed planning a building to prevent fire from spreading internally and to preserve the structural members.

Designers had already devised a way to minimize the negative effects of thick walls, which was to concentrate the wall material between the windows rather than spread it uniformly through the wall. The name for the parts of the wall where the weight-bearing material was concentrated was *piers*. Boston's 1885 building law specifically provided for this kind of wall construction.²⁸ While this approach allowed for larger windows, it also left deep masses of wall between them. Some designers attempted to reduce the bulk of these piers, when permitted by the codes or exceptions, by reinforcing them with iron columns and dispensing with some wall material.²⁹ (Illustration 6-2.)

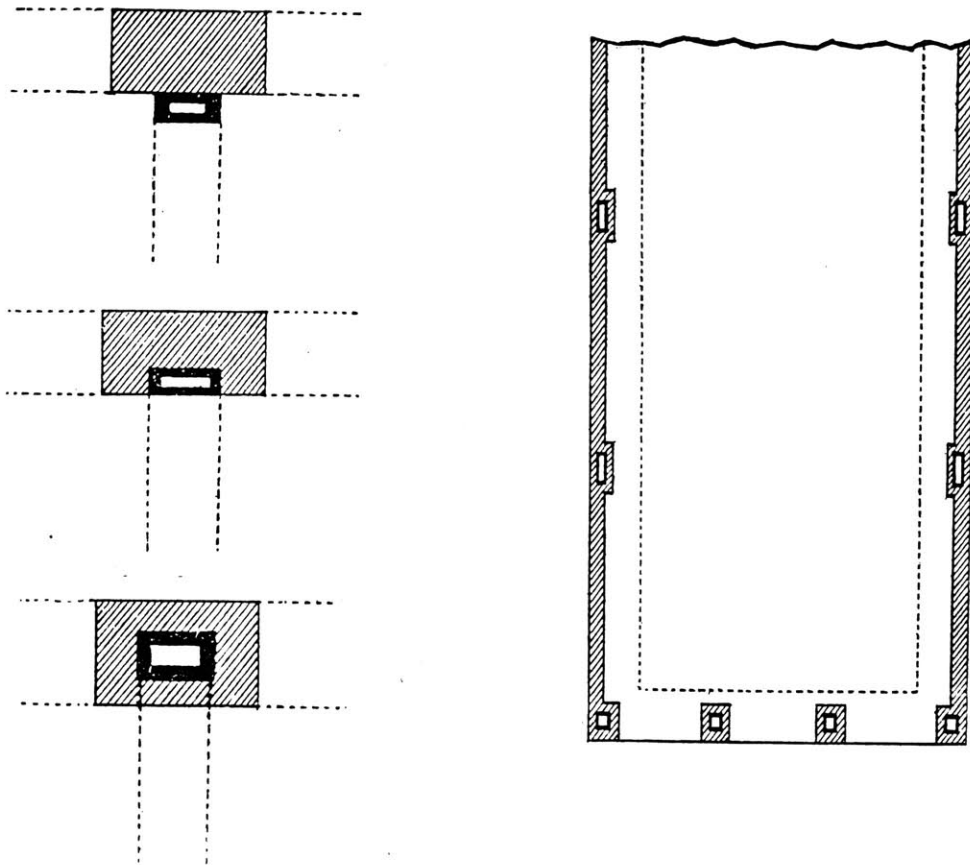
The skeleton system probably developed from this idea of using columns in piers: instead of having the column reinforce the pier, which carried the load, the column itself took the entire load. Walls facing the interior courts of a few buildings constructed in the 1880s may have been true skeleton frame construction.³⁰ Buildings that are considered the pioneer skeleton buildings used skeleton frame construction in the street facades, demonstrating thereby that a whole building could be constructed this way.

²⁸ Chapter 374 of Acts of 1885, section 48.

²⁹ William J. Fryer, Jr., "Skeleton Construction, A New Method of Constructing High Buildings," Architectural Record vol. 1 (1891-92), p. 231, and Louis De Coppet Berg, "Iron Construction in New York City, Past and Future," Architectural Record vol. 1 (1891-92), p. 463.

³⁰ For example, the interior courtyard wall of the New York Produce Exchange (1881-1884), designed by George B. Post, was made of iron columns and girders, with the space between filled in with brick. (Engineering Record vol. 34 (July 11, 1896), p. 103.) Also, according to Peter Wight, who was the floor arch contractor on the building, the courtyard wall of the Phoenix Insurance Building (later the Western Union and then Austin Building) in Chicago, completed in 1886, was carried by the frame. (IA vol. 19 (March, 1892), p. 22.)

Illustration 6-2. Migration of columns into walls. Also, a plan comparing the amount of a lot taken up by bearing and skeleton walls for a tall building (bearing walls are indicated by the dotted line).



What to do with the walls, in this system, was a question. The walls could be built so as to carry themselves; in this case, the walls were independent of the interior structure. Some contemporaries referred to this type of construction as skeleton, but others distinguished it from the true skeleton system by naming it the "cage" system.³¹ Another solution was to put the walls, as well as the floor, roof, and everything else, on the framework of columns and beams. This idea was accomplished by carrying the walls on girders, which were put at

³¹ William J. Fryer, Jr., A History of Real Estate... in New York, pp. 464-465.

every story or every other story. Such buildings are true skeleton frame buildings. Unlike a bearing-wall structure, the walls in the lower stories of a skeleton building are no thicker than those in the upper stories. These walls just kept the weather out, held the window frames in place, gave a good appearance to the exterior, and protected the building from fire. This was a new kind of wall, as one contemporary explained; it was "only a mask ... not a wall, in the proper sense of the word."³² Early on, these walls were conceived of as a curtains, and the walls of skeleton buildings are called "curtain walls."³³

A few people claimed to have "invented" the skeleton frame, but contemporaries rejected these assertions. Most agreed that the system was an evolutionary product and that credit for the invention should go to "the American architect" rather than to any one individual.³⁴ In the opinion of William Fryer, who was very much in the midst of the development process, "The system may be said to have been incubated, rather than invented, and the simple, triumphant method of constructing the most marvelous of modern buildings is found upon examination to be but an enlarged use of preceding methods."³⁵ These "preceding methods," of course, were the methods of constructing fireproof buildings.

Contemporaries did disagree about where this evolution was most fruitfully taking place: Chicagoans thought it was their home town, but New Yorkers also claimed precedence. In fact, the skeleton system appeared in both cities at about the same time, at the end of the 1880s. It is fair to say, though, that structural invention proceeded faster in Chicago in the 1890s than in New York, once the initial idea had been introduced, which is why at least one New York structural engineer could acknowledge that "the majority of writers call it the 'Chicago Steel Skeleton Construction.'"³⁶ The specific problems that

³² Peter Wight, "Recent Fireproof Building in Chicago," part II IA vol. 19 (March, 1892), p. 22.

³³ William J. Fryer, Jr., "Skeleton Construction," p. 228.

³⁴ See, for example, correspondence concerning this question in Engineering Record vol. 34 (July 11, 1896), p. 103.

³⁵ William J. Fryer, A History of Real Estate ... In New York, p. 466.

³⁶ William H. Birkmire, Skeleton Construction in Buildings 3rd edition (New York: John Wiley & Sons, 1900), p. 3.

precipitated the introduction of the skeleton frame in each city were different. In neither case was it introduced in order to solve the problem of building higher.

In New York, a local condition that magnified the disadvantages of tall, bearing-wall buildings was the small size of lots in Lower Manhattan. The pioneer skeleton frame building in this city, the 129 foot Tower Building (1888-89) at 50 Broadway, was on a lot that measured just 21 1/2 feet across. The building law in effect in 1888 required that the ground floor walls of buildings over 115 feet high be 32 inches thick, meaning that the interior width of the building at street level would have been about 16 feet.³⁷ To increase the leasable area on the lower floors, the building's architect, Bradford Gilbert (1853-1911), planned a building in which the floors and walls throughout most of the building were carried on girders. Since this kind of construction was not allowed under the building code, the architect applied for an exemption, arguing that it met the standard of being "an equally good and more desirable form of construction." The Board of Examiners was skeptical, but granted permission. The building had cast iron columns, rolled iron girders, and hollow tile floors from Maurer & Son.³⁸

Other developers immediately appreciated the importance of this idea. The second skeleton frame building in New York, likewise, was a tall -- ten story -- building on a narrow lot (24 feet 2 inches wide): the Lancashire Fire Insurance Company building at 25 Pine Street. It was designed by J. C. Cady & Co. and built 1889-90.³⁹ By the next year, the development of the skeleton was already being chronicled: William Fryer wrote an article on the evolution of the system for the first volume of the new architectural periodical, Architectural Record.⁴⁰

³⁷ William J. Fryer, Jr., "A Review of the Development of Structural Iron," A History of Real Estate ... in New York City, and William J. Fryer, Jr., Laws Relating to Building, in the City of New York ... (New York: The Record and Guide, 1887).

³⁸ "Leading Building Material Firms," A History of Real Estate ... in New York, p. 427.

³⁹ W. J. Fryer, Jr., "A Review .. of Structural Iron."

⁴⁰ William J. Fryer, Jr., "Skeleton Construction, A New Method of Constructing High Buildings," pp. 228-235. Another article in the same volume reviews the development of skeleton construction in New York: Louis De Coppet Berg, "Iron Construction in New York

In Chicago, where property owners in the geographically circumscribed commercial center also were building higher and higher, the motivation for reducing the dimensions of walls was not narrow lots, but to solve the problem supporting heavy buildings on Chicago's compressible soil and to reduce obstructions to natural light inside the buildings. The thirteen story Tacoma Building (1887-89), in which the walls of its two streets facades were carried on the frame (the alley and party walls, and the interior bracing walls, were load-bearing), is usually considered the first building there with skeleton walls.⁴¹ This building was designed by the firm of Holabird & Roche, but the idea of building light walls of terra cotta blocks and carrying them on an iron frame did not originate with them. Rather, it was the terra cotta manufacturer and architect Sanford Loring who conceived of using his hollow blocks to solve the wall problem in this building; he proposed the idea to the architects, who used a variation of it in the Tacoma.⁴² And in fact, hollow tile blocks were used in the construction of walls of the skeleton frame buildings to a greater extent in Chicago than in other places where weight was less of an issue; hollow tile floors also were universal at this time. The sixteen story Manhattan Building (1889-1890), designed by William Le Baron Jenney, was the first in Chicago with a full skeleton frame.⁴³ Skeleton frame buildings quickly multiplied in this city. Some early examples are the Rand McNally building by Burnham and Root (1889-1890), and Jenney & Mundie's Leiter Store (also called Siegel, Cooper and Co.) and Ludington Building, both completed in 1891.⁴⁴

The skeleton system spread to other cities. In Boston, perhaps the first skeleton structure was the 1893-1894 Winthrop Building, a nine story building on an small, irregularly-shaped lot at Devonshire and Water Streets, designed and owned by Clarence

City, Past and Future."

⁴¹ Frank Randall, History of ... Building Construction in Chicago, p. 13.

⁴² H. J. Burt, "Growth of Steel Frame Buildings; Origin and Some Problems of the Skyscrapers," Engineering News-Record vol. 92 (April 17, 1924), p. 681. Thanks to Cecil Elliott for this reference.

⁴³ Frank Randall, History of ... Building Construction in Chicago, p. 23 and p. 120.

⁴⁴ Frank Randall, History of ... Building Construction in Chicago, p. 124.

Blackall.⁴⁵ It had tile floor arches, supplied not by one of the prominent Chicago or New York hollow tile manufacturers, but by the Lorillard Brick Works Co., indicating that structural tile was becoming a commodity. The six story addition to the Drexel Building in Philadelphia (1887-1889, designed by Wilson Brother & Co.) is sometimes mentioned as being the first skeleton building, but it was largely a wall-bearing structure.⁴⁶

At the same time, architects were building cage-type buildings. The architect George B. Post advocated this system and designed a number of cage style buildings. His thirteen story World (Pulitzer) Building, built 1889-90, was considered an "extreme example" of a building of this type.⁴⁷ Including the six story dome, the building rose 275 feet above the street. At the ground floor, the walls, which supported themselves only, were over 11 feet thick. As might be supposed, this building was on, for lower Manhattan, a large lot.

Some architects continued to build cage system buildings in the 1890s, with outside walls independent of the interior frame, because they feared that unequal expansion rates of masonry and structural iron could result in cracked walls. This concern was soon laid to rest (the difference in rates is negligible) and true skeleton frame became the dominant system for tall buildings.

While the materials of the early skeleton buildings were the same as those used in wall-bearing fireproof buildings, there was one exception, and this was steel. Practically from the beginning, this system of construction was called "steel skeleton." Structural steel was by no means a precondition for building a skeleton, and the pioneer skeleton frame buildings -- the Tower, Tacoma, and Manhattan -- were built principally of cast and wrought iron. Nor was steel a defining characteristic of a skeleton frame: cast iron columns continued to be

⁴⁵ Charles S. Damrell, A Half Century of Boston's Building (Boston: Louis P. Hayer, 1895), pp. 70-71 and Boston Landmarks Commission, Building Information Form, CBD area, for the Winthrop/Carter Building.

⁴⁶ Engineering Record vol 34 (June 27, 1896), p. 71. A description of the construction system in this building is in George Tatum, Penn's Great Town (Philadelphia: U. of Pennsylvania Press, 1961), pp. 114-115 and figure 124.

⁴⁷ Quoting J. K. Freitag, in T. Nolan, ed., Architects' and Builders' Pocket-Book 16th edition (New York: John Wiley & Sons, 1916), p. 234. Fryer considers the building a "notable example of cage construction," in History of Real Estate...in New York, p. 465-66.

used in skeleton frame buildings in the 1890s and early 1900s. Yet in skeleton buildings, for the first time, entire frames were made of steel, and steel was important to the ultimate development of the system.

Steel or Iron?

The product of Bessemer's converter and the later methods of refining pig iron that replaced puddling, was called "steel" although it little resembled the material long used for cutlery, tools, springs, and railroad tires, besides being made in a completely different way. This engineering "steel," as the prominent builder, William Starrett, explained to the public, was "a wholly new iron intermediate between wrought and cast, lacking the essential hardness of true steel, free from the slag of wrought-iron, yet having the latter's malleability."⁴⁸ Engineering steel, or "mild steel," contained less carbon than cast iron but more than wrought iron. It is the presence of carbon that makes cast iron strong in compression although brittle, among other things; the virtual absence of carbon in wrought iron makes it malleable. Engineering steel, thus, was stronger than wrought iron for beams (in tension) and also well-adapted for columns (in compression).

Although two methods for manufacturing the new steel were in use by the time steel production commenced in the U.S., in the second half of the 1860s, the overwhelming proportion of American steel was produced with the Bessemer method. The number of Bessemer plants grew in the early 1870s and output increased steadily, even as the price of steel slumped during the depression of that decade.⁴⁹ Practically all of this steel was soaked up by the rail mills. For this reason, although Bessemer steel could be made in different grades, U.S. steel makers had no incentive to produce any but low end, rail grade steel.⁵⁰ This grade of steel was considered unsuitable for structural work: in the U.S., mild steel was used in very few bridges and no buildings before 1885.

Nevertheless, steel had several qualities, besides its greater tensile strength, that made

⁴⁸ William Starrett, Skyscrapers and the Men Who Build Them (New York: Charles Scribner's Sons, 1928), p. 36.

⁴⁹ Peter Temin, Iron and Steel in Nineteenth Century America, pp. 171-173.

⁵⁰ Gustavs Henning, "Notes on Steel," A.S.M.E. Transactions vol. 4 (1882-1883), p. 410.

it attractive to constructors. For one thing, unlike wrought iron made by puddling, the new steel was made by completely melting pig iron and this meant that the entire product of a melt was uniform in its properties. Also, mild steel could be produced in large batches and therefore structural shapes could be rolled from one mass of the material, or billet, rather than made up of pieces welded together, as was done with wrought iron. For these reasons, engineering steel was described as "homogenous," a quality that was valued. Another advantage of steel, which it shared with wrought iron, was that connections between columns and beams could be made with rivets and therefore would be stiff. Very tall buildings with light walls were vulnerable to twisting from wind pressure, and in these buildings, a stiff and braced frame was highly desirable (or essential). Rivetted connections were not possible with cast iron columns; connections with cast iron members were made with bolts and would inevitably have some play around the bolt hole. Finally, constructors had more confidence in metal that had been rolled, since it was less likely to contain imperfections. A great objection to hollow, cast iron columns was that defects -- e.g., cavities in the walls and floating cores -- were hard to detect.

While the new steel was attractive, nevertheless little was known about how well it would perform in structural work. In the 1870s, architects and engineers convinced Congress to appropriate funds to pay for a testing program in order to obtain necessary information about American metals. Their rationale for federal government sponsorship was the same as the one used in the 1850s, when funds were requested for tests of rolled iron beams at Trenton: since the government consumed so much iron and steel in its fireproof buildings, money was likely being wasted in the customary over-design of buildings due to ignorance of the true capacities of the various materials.⁵¹ Congress did appropriate funds, and various committees under a body with the unwieldy name United States Board Appointed to Test Iron, Steel and Other Metals set to work at the Watertown Arsenal in Massachusetts. But the Board was short lived. The government funds mainly bought a unique testing machine,

⁵¹ William Sooy Smith, Chairman of the Committee on Tests of Iron and Steel of the A.S.C.E., in Message from the President of the U.S. transmitting the report of the board appointed to test iron, steel, and other metals ..., June 8, 1876 (Senate Exec. Doc. no. 71.)

capable of testing full-sized structural members, not just scale models. After Congress discontinued funding the Board in 1879, the laboratory at Watertown continued to make tests, for the government and also for private clients on a fee for service basis.

The Board's work resulted in refinement of mathematical formulas for engineering, but many questions about the materials themselves remained unanswered when it disbanded. In the early 1880s, with respect to the performance of actual pieces of metal, concerns persisted because of the lack of standardization in the output of steel furnaces.⁵² As late as 1889, Americans were still looking for guidance on the reliability and merits of steel compared with wrought iron. A report by a committee from the Ponts et Chausees in France was influential; it concluded that the manufacture of steel had so improved that it could be used in place of iron in bridge building.⁵³

Even as experimental results were indicating that steel was stronger than wrought iron for beams, a great disincentive to using steel remained, which was that beams made of steel cost more than beams made of iron. Even when steel had replaced wrought iron for rails at the end of the 1880s, the price of wrought iron beams remained high. The wrought iron that had formerly been devoted to rails was not now available for beams, which might have brought down the price of beams; rather, wrought iron production was simply scaled back. Moreover, American rails had to compete with imported British rails and this competition helped keep rail prices down. Britain did not export rolled iron beams to any great extent; by the end of the century, it was importing Belgian and German iron beams.⁵⁴

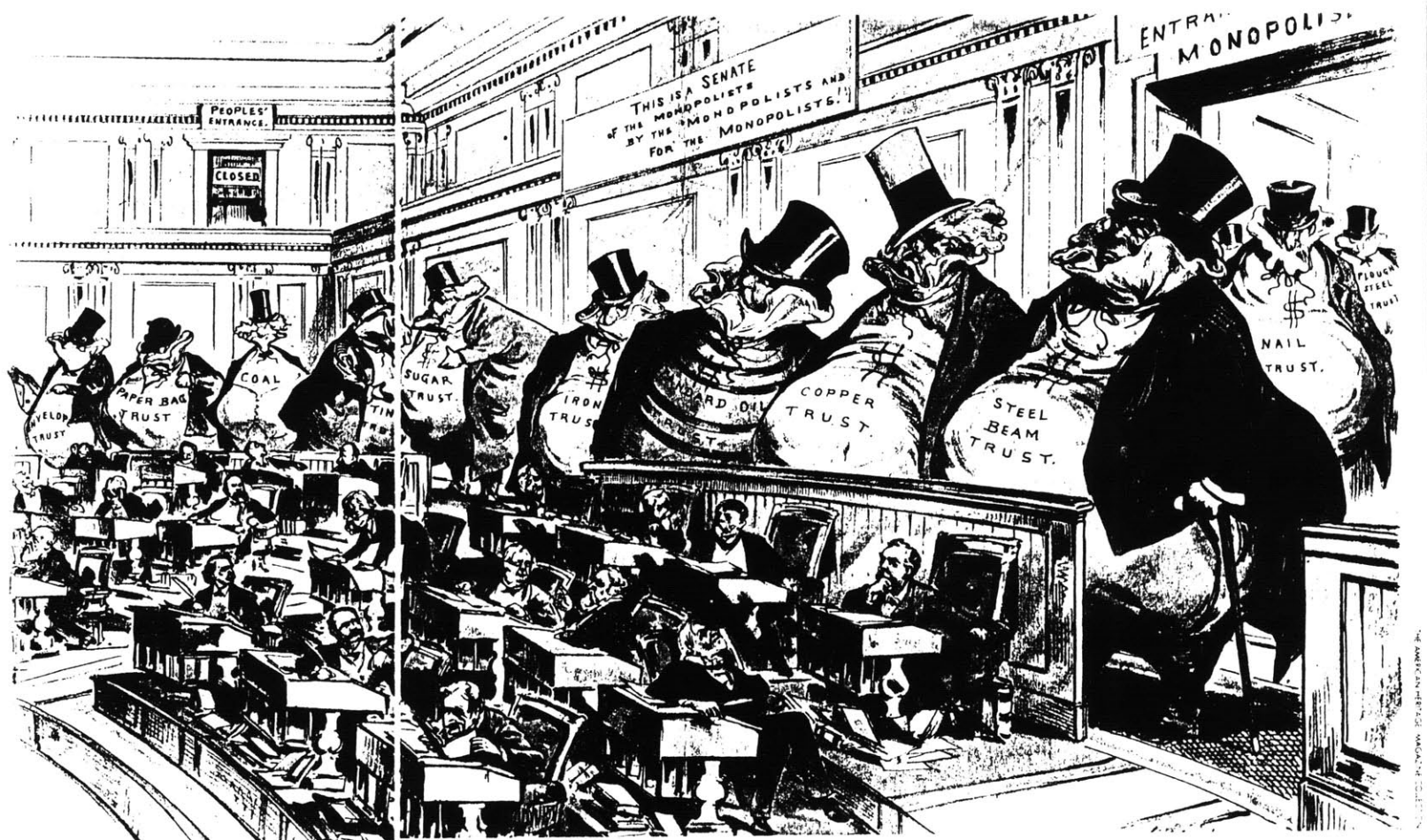
Many commentators charged that the high prices both of wrought iron and steel structural shapes were due to collusion among producers. The "mill pool" or "combinations" of manufacturers fixed prices and enforced them by persuading Congress to keep tariffs high enough to exclude imports. An 1888 editorial in AABN quotes the New York Times as saying what "we all know:" that "the American rolling-mill combination has fixed the price

⁵² Robert H. Thurston, "Annual Address -- the Mechanical Engineer," A.S.M.E. Transactions vol. 4 (1882-1883), pp. 76-77.

⁵³ AABN vol. 25 (June 22, 1889), p. 289.

⁵⁴ Lawrance Hurst, "The Age of Fireproof Flooring," p. 39.

Illustration 6-3. 1887 cartoon from *Puck* illustrating the relative influence of the trusts and the public in Congress. The most prominent moneybag is the Steel Beam Trust.



of its beams at three and three-tenths cents per pound." AABN tried to show how unreasonable this price was by comparing it with the price of imported Belgian beams. AABN claimed that these beams, even with freight, insurance, etc., and an estimated 120 percent ad valorem tariff rate, could still be had in seaport cities for less than domestic beams.⁵⁵ "There is no reason," AABN charged, "why steel rails should be sold at our mills for a little more than a cent a pound, while steel beams, rolled in the same way, out of the same material, should cost more than twice as much," except, presumably, for the lack of competition.⁵⁶ The extortionate beam prices discouraged better building, many believed. (Illustration 6-3.)

Despite the high price, steel beams were being adopted for building construction. In the 1890 building season in Chicago, a great increase in "fireproof work" created a such a demand for steel beams that mills were unable to keep up and buildings were delayed. Nevertheless, the prominent architect William Jenney advised architects to use steel. The price per pound of steel and iron beams was the same, he argued, while steel could be figured at a fourth to a third stronger. Consequently, lighter, less expensive, sections could be used. Jenney assumed that the steel would be Bessemer and so he also recommended that an agent of the architect test the tensile strength of each "blow" and that each beam be inspected for defects. Although these inspections added to the architect's costs, they were necessary and ultimately good for his business since "there is no other detail in an architect's practice by which he can save so much money for his client" as switching to steel.⁵⁷ Jenney predicted that steel production would continue to improve, the price of steel would fall, and that "before long every hotel, apartment house, theater, and schoolhouse will be fireproof."⁵⁸

Despite price fluctuations and bottlenecks at times -- such as during the busy 1890

⁵⁵ AABN vol. 24 (Oct. 27, 1888), p. 189, with figures corrected in vol. 24 (Nov. 17, 1888), p. 236. AABN used the wrong number to convert kilograms to pounds at first, but with the correct figure, the point that the specific duty was equal to the price of beams in France and Belgian stood.

⁵⁶ AABN vol. 26 (Dec. 28, 1889), p. 297.

⁵⁷ IA vol. 14 (Jan., 1890), p. 94.

⁵⁸ IA vol. 16 (Dec., 1890), p. 77.

building season -- the prices of iron and steel beams began trending downward in the 1890s. Perhaps contributing to the fall in price was growing competition, following the dissolution in 1892 of the reviled "combination of manufacturers, which has kept up the price of iron beams ... for more than twenty years."⁵⁹ By the middle of this year, steel beams were available at Pittsburgh and Chicago for two cents per pound, which, given its greater strength, brought the cost of structural metal down to about half of what it cost two years before. There no longer was a need to import iron beams. With this reduction, AABN predicted, fireproof construction would increase,

Our methods of fireproof building are already very perfect, and are constantly being improved, but the enormous cost of structural iron required has made it impossible to use those methods except in rare cases. Now, with the lower prices for iron, its field of use will be greatly extended. Many a building will bring in rents sufficient to pay interest on the cost of fireproof construction with iron at two cents a pound, which would not do so with iron at three cents; and the fireproof construction will be adopted, to the great advantage of all concerned.⁶⁰

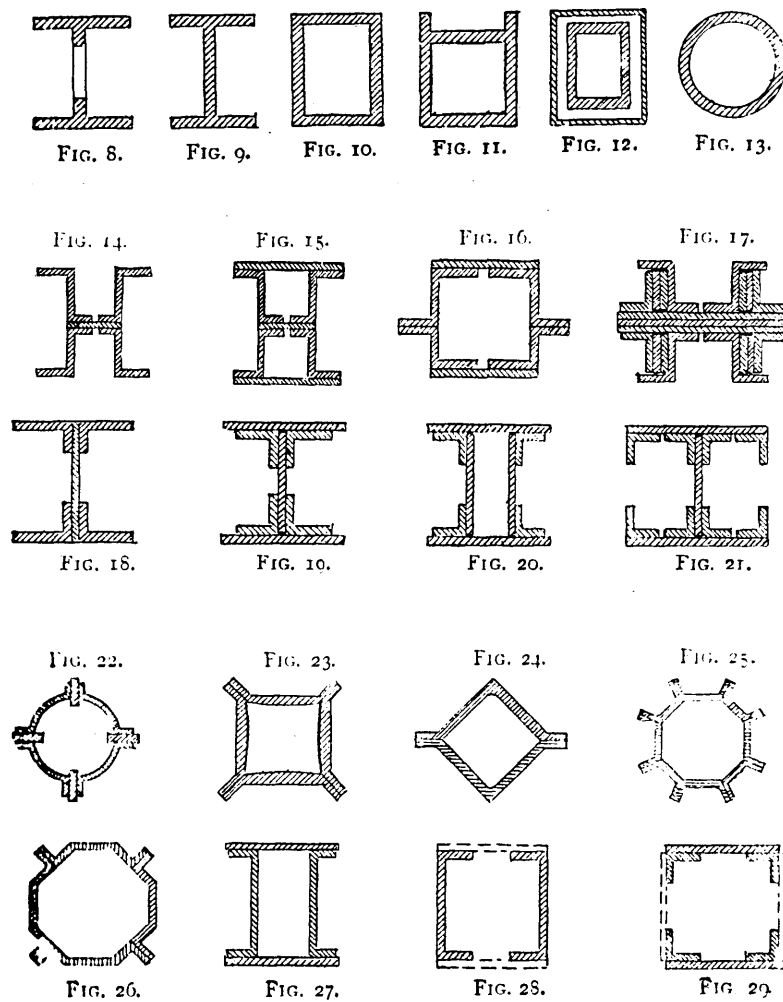
Even as some designers were using steel beams, steel columns were still relatively rare in the early 1890s. Steel was easily substituted for wrought iron in beams: whether of iron or steel, beams were solid and shaped like an I. Columns were much more varied with respect to material and shape. The disincentive to steel columns was the high cost, although they were used in some of the earliest skeleton buildings, especially in Chicago. But in New York, cast iron columns continued to be used. The cast iron columns in exterior walls were usually square or rectangular in section. Rolled columns made of wrought iron or steel, were available in a variety of shapes: Z-bar patterns; patterns made of shallow U channels and plates or lattice connections; and columns made of specially shaped, riveted pieces, such as the Phoenix, Carnegie, and Jones & Laughlin patterns. (Illustration 6-4.)

The choice of columns depended on the overall design of the metal framework. Many architects preferred cast iron columns while Z-bar columns were "the favorite with engineer constructors" who were increasingly involved on tall building projects. Z-bar columns may have worked well in bridges but not in buildings: the connections between columns of this

⁵⁹ Summary, AABN vol. 35 (Feb. 13, 1892), p. 97.

⁶⁰ Summary, AABN vol. 36 (June 4, 1892), p. 142,

Illustration 6-4. Column patterns. Top row, cast iron; middle, rolled shapes; lower, patented section.



shape and beams and successive columns were awkward, and, as interior posts, when fireproofed and plastered, Z-bar columns occupied more space than any other shape.⁶¹ Columns made of channels equal in strength to Z-bar shaped columns had a smaller section and easier connections. Phoenix columns were long the only wrought iron columns generally

⁶¹ Peter Wight, "Recent Fireproof Buildings in Chicago, Part III," pp. 32-33.

used in building construction,⁶² and in the 1890s, they began to be made of steel.

But the structural design was not the only consideration in the shape and material for columns. Columns in a building were structurally more important than beams; a column collapse could bring down the interior of a structure, while the failure of a beam would likely affect only the floor sections the beam supported. Therefore, the fact that questions remained concerning the fire and corrosion resistance of steel columns may also have slowed adoption. Compared with cast iron, wrought iron rusted more readily and in a fire, weakened at a lower temperature; presumably, steel would perform like wrought iron. Steel bridges did not offer much guidance in this regard. Unlike bridge members, structural metal in a building was encased in fireproofing and could not easily be inspected or repainted to protect against rust. Some designers also worried that unequal rates of expansion of columns and masonry subjected to great temperature swings would cause walls to crack, hence the preference of some for independent walls (cage construction). Cast iron expanded and contracted less than steel. These qualities, plus the comparatively lower cost of cast iron, recommended cast iron for columns and even for spanning members used in the exterior walls of tall buildings.

There were some projects -- the tallest buildings and buildings that were subject to vibration -- in which rivetted connections were highly desirable. Since skeleton buildings lacked the ballast of bearing walls, the tall ones, especially, required special bracing against wind, which was difficult to accomplish with cast iron columns. Some architects early on appreciated the advantages of rigid connections for skeleton buildings that were very high relative to their small footprints. The entire frame of the Lancashire Building, an early skeleton building in New York, was riveted wrought iron.⁶³ Nevertheless, designers at first used wrought iron and steel columns in a post and beam form of construction, with the girders resting on column caps. Not until 1894, in the reconstruction of the Reliance Building in Chicago, were girders first attached with brackets to the columns -- an advance that was

⁶² In 1887, the engineer C. W. Trowbridge predicted that "wrought-iron gaspipe" would come to be more commonly used; they were already being used in iron store fronts. The drawback of gaspipe was connecting the pipe to beams. (*IA* vol. 9 (June, 1887), pp. 77-78.)

⁶³ Louis De Coppet Berg, "Iron Construction in New York City, Past and Future," pp. 463-464.

necessary to create a truly rigid frame.⁶⁴

Besides the question of the height and intended use of a building, the decision to use iron or steel columns was also affected by whether a bridge engineer was involved with the design. In the 1890s, bridge shops and consulting engineers with experience in bridge work began to bid on the iron contracts for buildings. The bridge shops naturally preferred to supply rolled structural shapes rather than castings. Bridge engineers no longer used cast iron structurally, and they inevitably specified steel or wrought iron columns for buildings. Bridge engineers were involved with the early skeleton buildings in Chicago in which steel columns were used. One of the earliest buildings there with steel columns was the Rand McNally Building, mentioned above, for which the civil engineering firm Wade & Purdy designed the steelwork.⁶⁵ It featured the Z bar-shaped columns in its street and rear walls (the side walls were bearing). Wade & Purdy also designed the steelwork for another of the earliest Chicago buildings with steel columns, the Caxton building (completed 1890). An engineer was also behind what was probably the first buildings with steel columns in New York, the Columbia Building at 29 Broadway, built 1890-1891; the steelwork in this building was designed by P. Minturn Smith, President of Union Iron Works.⁶⁶

After the "constructive steel combination" collapsed in 1892 and then the building boom ended in the depression of 1893, and the prices of steel structural shapes declined.⁶⁷ Production of iron beams dwindled in the 1890s and in 1894, when the price of steel columns fell, the number of frames made entirely of steel began to increase. The ultimate consequence of this competition between the foundries and the mills was that architectural iron works, once so numerous in cities, began to disappear. Only about a half dozen

⁶⁴ E. C. Shankland, "Steel Skeleton Construction in Chicago," p. 56.

⁶⁵ Frank Randall, History of ...Building Construction in Chicago, pp. 118-120.

⁶⁶ William J. Fryer, Jr., A History of Real Estate ... In New York, p. 471-473. The building was designed by Youngs and Cable.

⁶⁷ Peter Wight, "Recent Fireproof Buildings in Chicago, Part III" IA vol. 19 (April, 1892), p. 33.

architectural iron works remained in New York City at the turn of the century.⁶⁸

Nevertheless, through the end of the century, cast iron columns could still be had for less than steel and for smaller buildings, there was no advantage to using steel. For this reason as well as fire and corrosion resistance, and undoubtedly also because they were familiar, many architects braved the abuse heaped on them by bridge engineers and continued to use cast iron columns. Cast iron had been abandoned for structural work in bridges in the 1880s, for reasons that were irrelevant to its suitability in most buildings. Bridges were subjected to great intermittent shocks and vibration, conditions that wore out cast iron by causing little fractures in a naturally brittle material. Consequently, when cast iron broke, it broke suddenly, which gave it a reputation for being "treacherous." But in buildings with steady loads and not subject to significant wind pressure, the choice of material to use for columns came down to cost. Architects used various methods to test cast iron columns for defects, including drilling them, measuring the thickness of the walls with calipers, and rolling them;⁶⁹ it was also customary to order the column walls to be made thicker than necessary, as a safety precaution. Although this added to their cost, the columns still must have been cheaper than steel in some markets, which seemed to include New York. Perhaps three-quarters of all buildings of twelve stories or less constructed in New York at the turn of the twentieth century had cast iron columns.⁷⁰ In Chicago, on the other hand, steel columns were more widely used.

Another great advantage of the skeleton system was the speed with which a building could be constructed. Formerly, the additional time required to build fireproof was one of the disadvantages of the system. The buildings rose slowly, often held up by the rolling mills, which were slow in fulfilling orders. But with skeleton frame construction, buildings were becoming taller yet took no more time to construct than shorter ones. The reason for this was

⁶⁸ A History of Real Estate ... in New York, p. 487 and p. 498.

⁶⁹ John R. Freeman, "Some Notes on Fire Protection Engineering," a lecture before the engineering students of Cornell University, delivered May 4, 1894.

⁷⁰ Estimate by the engineer Alfred F. Evans who condemned the use of cast iron columns. New York Times, March 13, 1904, p. 20.

that in a skeleton building, the metal frame was erected first and then work on several floors could proceed simultaneously, rather than a floor at a time. Hollow tile floors were set before the exterior walls were built. Shorter construction times meant big savings for the developers: buildings were ready for occupancy and could start earning income sooner, and the developer's cost of capital during the construction phase was reduced. For this reason, skeleton construction was also adopted for shorter buildings.

The Fire Tests of the Early 1890s

Although the number of fireproof buildings was increasing, few had actually had been tested in fires, and no one could say definitively whether the "modern" methods would work as intended. Could a very hot fire in the contents of a building break the tile fireproofing, expose the metal structure, cause the metal to expand, twist, and bend, and lead to the destruction of the building? In the early 1890s, several fires in new, tall buildings provided reassuring answers to this question.

The fire in the Lumber Exchange building in Minneapolis in 1891, mentioned in Chapter 4, was such a test. To recapitulate the circumstances, the Lumber Exchange Building (Long and Kees, architects) was built in two phases. The first section was nine stories "of the most approved slow-burning construction," made with iron columns and girders, and wood joist floors; all structural parts were protected with tile. At the time of the fire, an eleven story, fireproof addition -- an iron frame and hollow tile building -- was under construction, and two stories of the same type of construction were being added to the original building. Part of the work on the old building involved raising a water tank up to the new roof; a hole had been cut through the original floors in order to hoist the water tank, exposing the wood floor structure.

A fire started in a neighboring building and spread to the original wing of the Lumber Exchange, igniting the wood floor. Eventually, the roof tank fell in, breaking beams and dislodging fireproofing tiles as it came down. To compound the trouble, the fire was fought ineffectively. In the end, the interior of the original building was completely consumed; but, remarkably, the new tenth and eleventh floors withstood the blaze. The new wing was unoccupied, with little fuel for the fire, so was not severely tried. Nevertheless, it was little

damaged; its fireproofing was not even cracked.⁷¹

The next fire in a new style, fireproof building was a truly severe test. Finally "we have had an opportunity to judge the actual efficacy of the steel and fireproof construction" in a serious blaze, began a letter about the fire in AABN. The fire was in the ten story Chicago Athletic Club (Henry Ives Cobb, architect), which was still under construction at the time, in 1892. It started early on a Sunday morning and had spread to several floors by the time it was discovered. Piles of wood scaffolding, construction refuse, and painters' materials and rags were lying about, which made a blaze so hot that glass in some of the windows melted. The building was of cage construction, with floor arches, partitions, and column coverings made of porous terra cotta.⁷² On several floors, column fireproofing fell off; some columns were bent; and exposed beams over light wells were warped. Yet the fireproofing held up very well and protected the structure of the building. The cost of repairing the structural part of the building (as opposed to the finishes, which were completely destroyed) was expected to be minimal.⁷³ Two prominent engineers, hired by the building's owners to report on the damage, concluded,

This building furnishes an assurance that was lacking before -- that the metal parts of a building, if thoroughly protected by fireproofing properly put on, will safely withstand any ordinary conflagration if the quantity of combustible materials the building contains in not greatly in excess of that which enters into the construction of the building itself.⁷⁴

The building opened the next year. The lessons of this fire: mind the details of fireproofing and keep the amount of combustible material inside, even the decoration, to a minimum.

While these fires seemed to prove the worth of fireproof construction, they provided no guidance for selecting among fireproofing products. The great increase in the variety products was making the task of selecting materials increasingly difficult.

New Fireproofing Products

⁷¹ IA vol. 18 (Aug., 1891), pp. 7-11.

⁷² J. K. Freitag, Fire Protection and Fire Prevention, p. 241.

⁷³ AABN vol. 38 (Nov. 26, 1892), p. 132; IA vol. 20 (Nov., 1892), p. 32.

⁷⁴ AABN vol. 39 (Jan. 14, 1893), p. 28.

In the early 1890s, there was no single way to build a fireproof building. Unlike in the decades of the 1850s and 1860s, when there were few systems of fireproof construction, a great variety of materials were available for fireproof construction in the 1880s and 1890s. Segmental brick arches were hardly used at all any longer, save in ceilings over furnace rooms, in industrial buildings, and perhaps in the first floors of New York tenement houses, as required by the city's code.

The demand created by the tall, fireproof buildings encouraged both new products and producers to enter the fireproofing market. Indeed, some observers saw the improvement in fireproof building materials as driving the tendency to build tall. As IA noted, in dismissing a proposed ordinance to limit building heights in Chicago, "If high buildings have built up the fireproofing interests, it is certainly owing to the cheap and effective methods that have developed in the manufacture and placing of fireproofing material, as much as the improvements in elevators that have made high buildings remunerative."⁷⁵ The most important products in this decade fall into a few categories: hollow tile floor arches, notably "end construction" arches; combinations of tile and concrete floor systems; arch systems; and the most important new system, concrete floors.

Hollow Tile Floor Arches

Development in hollow tile floor arches in the 1880s was in the direction of increasing the span between beams: greater spans meant less iron, which might result in a savings in weight and cost, but also meant less iron that might be exposed to fire. The first styles of flat tile arches used in Chicago had spans of four to six feet between beams. In order to achieve longer spans, however, the flat arches had to be stronger. This was accomplished, in the 1880s, with internal walls, called webs, which were added to arch blocks. Blocks also were made bigger, which was no disadvantage, from the standpoint of the building, since the beams used for longer span arches were deeper too and the blocks simply filled the depth of the beam. However, the larger, many celled tiles represented a technological advance in tile manufacture. Tiles continued to be made of solid (also called "dense") and porous terra cotta, but in addition, a new material was introduced, called semi-porous terra cotta. It was made

⁷⁵ IA vol 13 (June, 1889).

of fire-clay and ground bituminous coal; the resulting block was less brittle than a dense tile block, but tougher than one made of porous tile.⁷⁶

The most important change in the design of arch blocks was the general adoption of "end construction" arches. Before the 1890s, a great variety of flat arch patterns were available, but all were of a type called "side construction," meaning that the cavity of the tile ran parallel with the beam. A few designs for floor systems in which the cavity of the block ran perpendicular with the beam had been patented in the 1870s, but they were little used if at all in that economically depressed decade. In the 1880s, tests of floor arches of this type were made in Chicago. By the end of the decade, several buildings in Chicago and other western cities had floors made of these "end pressure" or "end construction" style flat arches.⁷⁷ (Illustration 6-5.)

Illustration 6-5. Side- (top) and end-construction (bottom) arched arches.

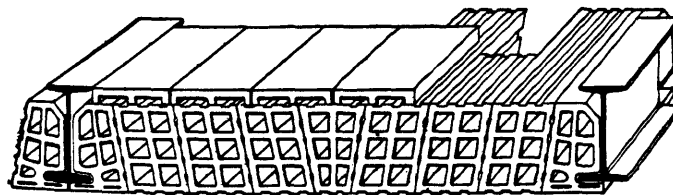


FIG. 33.—Terra-cotta Arch—Side-construction, Bevelled Joints.

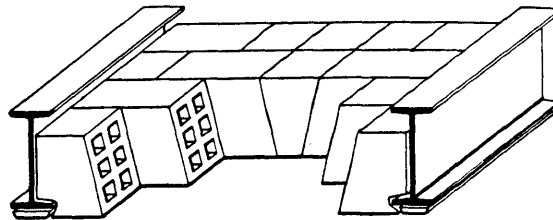


FIG. 35.—Terra-cotta Arch—End-construction.

Theoretically, these arches should have been stronger than side construction arches: the walls and webs of the blocks, running at right angles to the beams, were like webs of

⁷⁶ Joseph K. Freitag, The Fireproofing of Steel Buildings (New York: John Wiley & Sons, 1899), p. 90.

⁷⁷ Peter Wight, "Recent Fireproof Building in Chicago, Part IV," IA vol. 19 (May, 1892), p. 46.

beams. In December, 1890, this theory was put to a widely publicized test. One of the three bidders on the tile contract for the Equitable Building in Denver, Thomas A. Lee, claimed that although his price was highest, his end construction style arch was stronger and more fire resistant than those of the other two bidders, and he requested that an objective comparison be made. His arch also differed in being made of porous tile rather than solid fire-clay like the others. The architects of the building agreed to conduct a test if the two other bidders, Pioneer Fireproof Construction Co. and Wight Fire-proofing Co., would participate. They did and all agreed to the test specifications.

At this time, no standards for how to test fireproofing materials existed. Whenever a manufacturer wished to show the merits of his product, he subjected it to a test of his own devising; the customer was left to decide if the conditions the product withstood in the test were likely to be the ones it might have to withstand in his building. Thus, every product had its own rating; they could not be easily compared. In the Denver case, three floors were subjected to the same tests, and so at least these three floor systems could be compared. The tests included a still load, shock (in which a log was dropped on the arch), fire and water, and continuous fire tests. The floors were to be tested to destruction.

It was no contest: Lee's arch outperformed the arches of the other two manufacturers decisively. Lee's arch sustained two to three times the weight without breaking and withstood ten drops of the log, while the other floors shattered on the first blow. Moreover, the porous terra cotta used to make Lee's arch withstood the fire and water and continuous fire tests better than did the solid tile of the other two arches, which disintegrated over the course of the test.⁷⁸

Peter Wight, in recounting this trial, implied that the test had been unfair in that Lee's tiles were made especially for the test while the tiles supplied by Wight and Pioneer were from their stock. Nevertheless, Lee's arch was what he proposed to make for the Denver building. Lee's arch also cost more than the arches of his competitors and Wight observed, quite reasonably, that although the other two arches did not perform as well as Lee's, they performed adequately and were still appropriate for many situations,

⁷⁸ "Tests of Fireproof Arches," AABN vol. 31 (March 28, 1891), pp. 195-201.

When all the service that is called for is obtained from a material, and it cannot be made lighter, nothing is gained by introducing stronger systems of construction. We do not build of granite because it is stronger than brick when brick will answer, and if the end-pressure system should be more expensive than the old one, there is every reason why we should adhere to the old one.⁷⁹

Nevertheless, Pioneer promptly introduced an end construction style of arch, as did Illinois Terra-Cotta Lumber Co., which were used in Chicago's prominent skyscrapers of the early 1890s. Peter Wight, on the other hand, left the increasingly competitive tile contracting business and resumed his architectural practice. After about 1894, according to the engineer Edward Shankland, end construction arches were universally used in Chicago.⁸⁰ Likewise in Philadelphia, at the end of the century, all tile floor work was end construction.⁸¹

Flat, side construction arches probably did not entirely disappear, and side construction blocks were still used in one application, which was in segmental, or curved, arch floors. The curved arches were very strong and could form very long spans, as much as twenty feet between beams, which allowed architects to dispense with intervening beams.⁸² Both Pioneer Fireproof Construction Co. and Wight Fire Proofing Co. made blocks for segmental arch floors. The second Leiter store (Jenney and Mundie, 1889-1891), and buildings constructed for the American Express Co., had curved arch floors.⁸³ The main drawback with this type of floor is that arched ceilings were considered unsightly by some; besides being curved, the arches were crossed with tie rods to contain the thrust. The curved ceilings complicated moving around partitions; owners desiring a flat ceiling had the expense of building one underneath the arch. They were used in warehouses, for example. But in office buildings, where a flat ceiling was wanted, the flat arches which formed their own ceilings, ready for a coat of plaster, were more commonly used.

⁷⁹ Peter Wight, "Recent Fireproof Building in Chicago, Part IV," p. 47.

⁸⁰ Edward Shankland, "Steel Skeleton Construction in Chicago," vol. 30 IA (Jan., 1898), p. 57.

⁸¹ Edwin Betolett, "Fireproof Construction in Philadelphia," Insurance Engineering (1901), p. 209.

⁸² Peter Wight, "Recent Fireproof Building in Chicago, Part V," IA (June, 1892), p. 57.

⁸³ Peter Wight, "Recent Fireproof Building in Chicago, Part V," p. 57.

Besides longer spans, tile manufactures also tried to create simpler shaped blocks. In the more elaborate flat arch floor styles, for example those with radiating webs, every block in the arch was different. These blocks were expensive to make and troublesome to lay. Manufacturers developed floors arches that consisted of only three different blocks: the skewback, key and intermediate block. But in some designs, even this variety was eliminated, and only two or even one block formed the arch.

A style of end construction arch introduced by Pioneer that was copied by other manufacturers was a block with many cells. It allowed for spans of up to twelve feet while safely supporting loads that were more than adequate for office buildings. Henry Maurer & Son introduced an arch block like Pioneer's, called the "Excelsior" block. Both of these arches had three different block shapes. The Maurer company introduced a variation of this floor at the end of the century, called the "Herculean" block. It dispensed with iron joists; instead the arch was reinforced with T-iron rods. Also, the arch was made of blocks of one shape and did not require skewbacks or a key, which simplified installation. The spans of this style floor were considerable -- up to nearly 23 feet, depending on the depth of the block -- so that the floors could span between walls and avoid girders.⁸⁴ They were used in a great variety of buildings at the turn of the century, including schools, factories, libraries, and apartment houses.

The structural tile industry had changed considerably from its early days in the 1870s. Tile was the most widely used material for fireproof floors, etc., in fireproof buildings at the turn of the century. The 1916 edition of Kidder's Architects' Pocket-Book listed National Fire Proofing Co., of New York and Chicago, as the largest one "devoted to the manufacture and erection of hollow-tile fireproofing material." Other companies described as "large" in Kidder include several that were important in the early days of the industry: Henry Maurer & Son, Haydenville Company, Illinois Terra-Cotta Lumber Company.⁸⁵ But other early companies -- New York Fire-Proof Building Co. and Wight's company -- had ceased

⁸⁴ Henry Maurer & Son, "Herculean Arch and Phoenix Wall Construction," (1908) trade catalogue, collection of the N.M.A.H.

⁸⁵ T. Nolan, ed., Architects' and Builders' Pocket-Book, 16th edition, p. 829.

operations; Pioneer apparently had been taken over by National Fire Proofing Co.

Combinations of Tile and Concrete Floor Systems

Two styles of floors are represented in this category. One style had the great advantage of being fast to install, by avoiding the need to set up the wood centerings required in tile arch floors. In these floors, tile or brick was set to make permanent centers; the base was covered with concrete, making these floors plain (not reinforced) concrete floors. Two examples of this type were popular in the Philadelphia area at the turn of the century: the Rapp floor and the Fawcett floor. The Rapp floor was patented and installed by John W. Rapp, who began his business in the mid-1880s. It consisted of a framework of iron T's carried on the lower flanges of I beams; the frame was filled with bricks and then the bricks were covered, the full depth of the beam, with cinder concrete. The floor framework could be either flat, curved, or *panelled*. The Rapp floor was inexpensive and was used in many apartment houses in New York, as well as apartment houses and office buildings in Philadelphia.⁸⁶ Another floor of this type was the Fawcett "ventilated" floor. The centers in this floor were terra cotta tubes that spanned, at a diagonal, between beams. They were simply placed, without mortar, on the lower flanges of the beams. Then, as in the Rapp floor, the area up to the top of the beams was filled with concrete. The floors could be laid very quickly. However, the span of the clay tubes was short -- about 2 1/2 feet -- so much iron was needed, although light sections -- usually 4 to 7 inch I beams -- were used.⁸⁷ These floors were well suited to residences, where the small beams could span between walls, and they were used in apartment houses. This style was notable in that it was an English import and was probably the only foreign floor system to have any success in the U.S.

In the other style of combination floor, tile blocks were used to lighted a reinforced concrete floor. In the case of one example, the Johnson Long-Span Flat Floor, the concrete floor was built under the tile blocks. A concrete layer, reinforced with metal fabric, was carried on I beams; hollow blocks, all one shape (end construction) were laid on top of the

⁸⁶ History of Real Estate ... in New York, pp. 431-32; Joseph K. Freitag, Fireproofing of Steel Buildings (New York: John Wiley & Sons, 1899), pp. 199-201.

⁸⁷ J. K. Freitag, Fireproofing of Steel Buildings, p. 203-206.

concrete and then covered with concrete. This floor required the centers of reinforced concrete construction.⁸⁸ The requirement for form-work, and the fact that it created a panelled ceiling, must have been a disadvantage; however, the floor could cover long spans, up to 24 feet, and it could be built very thin or very thick, depending on the strength required. Also, the tile blocks were all one shape (they were not the bearing part of this floor). A variation of this style of floor was the type of tile floor that continued to be used the longest, into the twentieth century.

Arch Systems

The principal representative of this kind of construction was tile arches made by the Guastavino Construction Company. This company made fireproof floors, domes, partitions, and staircases of layers of large, flat tiles set in cement. The arches were curved, and floors were made on top of them in two ways: either tile ribs were laid on top of the arch, and covered with two layers of tile on top, or else top of the arch was levelled up with cinder concrete. The main advantage of this system was that it could form very long spans entirely of tile, without intermittent beams. On the other hand, this system cost more per foot than hollow tile work⁸⁹ and it created segmental arch ceilings, although it did not require tie rods. The system was widely used, nevertheless, probably for the reason that the Guastavino arches were beautiful. The soffit of the arch did not require finishing because the tiles were a light colored fire-clay and, when glazed, were very attractive.

The Guastavino system was based on methods of construction used in Spain and adapted for modern buildings by the architect and contractor, Rafael Guastavino. He built a number of fireproof factories in Spain entirely of tile. Guastavino first made his ideas known in the U.S. at the 1876 Centennial Exhibition in Philadelphia, where he entered a "Plan for Improving the Healthfulness of Industrial Towns," for which he received a commendation.⁹⁰

⁸⁸ T. Nolan, ed., Architects' and Builders' Pocket-Book 16th edition, pp. 840-842.

⁸⁹ Peter Wight, "Recent Fireproof Building in Chicago, Part VI," vol. 19 (July, 1892), p. 69.

⁹⁰ R. Guastavino, "The History and Theory of Cohesive Construction," Oct. 24, 1889, 393rd meeting, M.I.T. Society of Arts, v. 7 (1886-1893); 1876 Centennial Exhibition, Philadelphia, Reports on Awards, Group 26, p. 569.

Not long after this he moved to the U.S. and opened offices in Boston and New York. Guastavino developed a theory of construction called "cohesive construction," which he contrasted with "gravity" construction, but in the U.S. he built parts of buildings, like other fireproofing contractors. The main applications of this system were for making fireproof ceilings over large spaces, such as church sanctuaries, libraries, lobbies, and public rooms. This system is better known today than practically all of the other fireproof floor systems of the time for the simple reason that, unlike the others, this one can be seen. One extant example is the corridors of Boston's absolutely fireproof Public Library in Copley Square, built 1888-1895 (McKim, Mead & White). More humble applications are the fireproof staircases in warehouses built for the Boston Wharf Company. The Guastavino company continued operations under Rafael's son, also named Rafael, well into the twentieth century.

Another arch system, invented by N. Poulson, was, like Guastavino's, based on a theory of building; its objective was to eliminate beams and posts and thereby reduce the cost and weight of fireproof construction.⁹¹ The system could not simply be added to a building; rather the building had to be designed according to the structural theory. It seems to have been used very little. Poulson was a principal a firm that made ornamental iron and bronze castings, Hecla Iron Works in New York.

Concrete Floors

"Concrete" is a mixture of some sort of adhesive material and water, sand, and a filling, called an aggregate. The adhesive material might be a natural one, such as plaster, lime, or natural cement, or a manufactured cement, called "Portland" cement. The aggregate could be broken stone, furnace ash or cinder, or even rubbish. It is necessary to define the material so generically because through most of the nineteenth century, "concrete" was not one thing. Only in the 1890s did the word in the U.S. come to mean exclusively Portland cement concrete. The new concrete construction systems introduced in this decade all were made with Portland cement. Cement concrete is strong in compression but weak in tension. Consequently, when used plain for spanning members, it is formed as a curved arch or is

⁹¹ N. Poulson, "Fire-Proof Construction," Society of Arts, Feb. 23, 1893, M.I.T. Society Records, vol. 7 (1886-1893), also in AABN vol. 39 (March 25, 1893), pp. 182-184.

made very thick, with short spans between supports. To make flat floors and use the material most efficiently, concrete has to be "reinforced" with iron or steel bars, which allows the floors to resist bending.

Americans used concretes relatively little in the first part of the nineteenth century. The principal uses were in civil engineering works, such as dams and bridge footings. The Army Corps of Engineers probably had the most experience with concrete as they used it in the construction of fortifications, and some Corps officers studied the material and its use by the French military. Concrete was used even less for structural purposes in buildings. It found its way into foundations -- for example, in the *grillage* foundations used in Chicago, and also had been used since the days of the masonry vault buildings to fill the tops of floor arches. However, in this latter application, the concrete merely leveled the floor and, when the brick arches were between iron beams, partly protected the structural metal. But it was dead weight, as the arch underneath carried the load. The only structural concrete floors in the U.S. before about the 1890s, as discussed in Chapter 4, probably were the Cornell and Gilbert floors, in which concrete covered corrugated iron plates.

In contrast, concrete was used to a large extent in buildings in Great Britain and France. In Great Britain in the 1850s, architects disenchanted with iron and brick fireproof construction turned to concrete systems for building fireproof floors. The first widely used concrete floor there was the Fox and Barrett system.⁹² This was a concrete bearing slab reinforced with closely spaced iron joists, similar to the styles of floors used in Parisian apartment blocks, e.g., Thausne and Vaux systems, built during the redevelopment period under Baron Haussmann. The differences between the English and French systems was the composition of the concrete and the nature of the reinforcing: the Fox and Barrett floor used only joists, while the French floors had small iron bars running perpendicular to the joists, which made the floor stronger. A number of other concrete floor systems were patented in Britain at about this time but perhaps because of the widespread mistrust among British architects of structural iron, the floors were essentially plain concrete, either in the form of arches or slabs between joists. The most widely used kinds in the 1860s were Phillips',

⁹² Lawrance Hurst, "The Age of Fireproof Flooring," p. 36.

Dennett's, and W. B. Wilkinson's floors.⁹³ An early example of a British reinforced concrete floor was patented by Matthew Allen in 1862. It consisted of a network of iron bars and concrete of Portland cement and cinders, a type of concrete that was later used in the U.S.⁹⁴ The potential advantages of concrete floors were that they could be lighter -- depending on how they were made -- and span greater distances than brick arches, without undue depth. The concrete systems replaced brick arch floors in non-industrial buildings in Britain until the end of the century.

At this time, and even later, British architects and engineers did not seem to appreciate the significance of iron reinforcement: how the mechanical properties of concrete and iron could be combined to make a product that was more than the sum of its parts. This phenomenon was demonstrated by an American, Thaddeus Hyatt. Hyatt was searching for "cheaper and more reliable fireproof constructions than those in common use," and in this connection, conducted experiments on concrete and iron at the engineering works of the respected engineer, David Kirkaldy, in London. He published his findings in 1877.⁹⁵ Hyatt

⁹³ Phillips' floor was made with small T iron between rolled iron joists and the concrete made with Portland cement. (Building News vol. 12 (Dec. 29, 1865), p. 925; Building News vol. 22 (March 29, 1872), p. 250.) Dennett's consisted of gypsum and an aggregate to make "Nottingham concrete." Floors built with it were plain, in an arch usually, although they sometimes were built between iron girders. This floor was used in a "long list of buildings," including government buildings, St. Thomas' Hospital, and at least one Yorkshire mill in the 1870s. (Building News vol. 12 (April 7, 1865), p. 243; G. M. Lawford, "Fireproof Floors," Transactions for 1889 Society of Engineers (1890), p.p. 45-46; Mike Williams with D. A. Farnie, Cotton Mills in Greater Manchester (Preston: Carnegie Publishing Ltd., 1992), p. 108.) W. B. Wilkinson & Co. made an arched floor of Portland cement, broken brick, and ashes, either without reinforcement, like Dennett's, or reinforced, if made flat to cover landings or corridors. Wilkinson's system was used in railway stations, a building at Edinburgh University, and "in many warehouses and stables." (Lawford, p. 46.)

⁹⁴ G. M. Lawford, "Fireproof Floors," Society of Engineers Transactions for 1889 (1890), p. 52.

⁹⁵ Thaddeus Hyatt, "An Account of some experiments with Portland-Cement-Concrete combined with iron, as a building material...", privately printed, 1877, in Howard Newlon, A Selection of Historic American Papers on Concrete (Detroit: American Concrete Institute, 1976). Hyatt was in England trying to sell the locals on his patented illuminating sidewalks, which consisted of an iron frame with glass disks designed to cover cellars that extended under a sidewalk.

shared with British architects a distrust of iron in a fire and his experiments centered on finding a way to securely encase iron beams. He started with the French floor systems, of closely spaced joists carrying perpendicular bars, and eventually discovered that a grid of small pieces of iron would give concrete the necessary tensile strength. He also concluded that the rates of expansion of concrete and iron were similar, so this combination was fire resistant.

Some American architects were acquainted with the British and French concrete systems, but probably did not experiment with concrete construction because so little of the best adhesive material for structural concrete -- Portland cement -- was produced domestically. The common mortar used in America was lime.⁹⁶ The "natural" cement made in the U.S. was too quick setting and too weak to work well for structural purposes.⁹⁷ Portland cement was called "artificial" because it was made by combining raw materials according to a recipe. Still, this did not make Portland cement a uniform product. The chemical composition and quality of what was called Portland cement varied. Portland cement was imported, but the quality of imported cement varied as well. At any rate, imported cement was very expensive. U.S. production of Portland cement began in the 1870s. Nevertheless, without uniformity in the material called cement, even Portland cement, and of concrete, constructors were at a loss to know why one system worked well and another did not.

Because of the high cost of cement, there was no advantage to using the Europeans systems for fireproof construction, even though American architects recommended concrete for fireproof construction.⁹⁸ A few experiments in concrete construction were made in the U.S. before the middle 1890s: the well-known William Ward house, built in Port Chester,

⁹⁶ In New York, where much natural cement was produced, cement was more commonly used in masonry walls than elsewhere. (AABN vol. 19 (March 6, 1886), p. 109.)

⁹⁷ Jasper Draffin, "A Brief History of Lime, Cement, Concrete and Reinforced Concrete," in Howard Newlon, A Selection of Historic American Papers on Concrete.

⁹⁸ For example, to architect and engineer N. H. Hutton recommended beton coignet for floors, stairs, and flat roofs, "Fire-Proof Construction," Scientific American Supplement, No. 10 (March 4, 1876), pp. 158-159.

New York in the 1870s and perhaps even the floors of the Southern Hotel in St. Louis. The Ward house was built with "4,000 barrels of imported Portland cement,"⁹⁹ an expense an inventor could justify for his own home, but a commercial builder could not. Some concrete slab floors were built in the U.S. in the 1880s, for example, one reminiscent of the Fox and Barrett floor was patented by the architect Frank Furness in 1888. A slab floor was used in the fireproof library building for the University of Pennsylvania, 1888-1890.¹⁰⁰ However, in this decade of great growth of fireproof construction, Americans turned to clay products for floors and roofs. Use of concrete blocks for floor arches -- the original product of the Fireproof Building Company of New York -- had more or less ceased in favor of tile.

The exception to this general direction was California, where Ernest Ransome was making a number of experiments in manufacturing and building with concrete in the 1880s.¹⁰¹ Ransome had come to San Francisco from England to begin manufacturing concrete stone according to his father's patented process. At the time, an local engineer in San Francisco was using Hyatt's reinforced concrete patents in construction.¹⁰² If the reason that concrete was not more used in the U.S. was because of the high price of one ingredient, it is curious that San Francisco alone had budding concrete construction. One explanation for this is offered by an unnamed "expert" in Fireproof magazine, who wrote that in San Francisco, when Ransome arrived, "English Portland cement was cheap. It was taken to California, freight free, as ballast for sailing ships that had taken out California wheat."¹⁰³ Ransome began to build reinforced concrete, too, also using bars, along the lines of Hyatt's principles. To improve the adhesion of concrete to iron, and dispense with the need to make a frame in tension, he twisted the reinforcing rods. His idea of a rough bar, which he

⁹⁹ "Concrete as a Building Material," AABN vol 2. (Aug. 18, 1877), p. 266.

¹⁰⁰ Patent no. 416,907. Described in The Architectural Era vol. 4 (June, 1890), p. 131.

¹⁰¹ E. L. Ransome and Alexis Saurbrey "Reinforced Concrete Buildings," 1912, in Howard Newlon, ed., A Selection of Historic American Papers on Concrete.

¹⁰² Walter Mueller, "Reinforced Concrete Construction," in Robert Lesley, Concrete Factories (New York: Cement Age Co., c. 1907), p. 64.

¹⁰³ Fireproof vol. 2 (July, 1903), p. 44.

patented in 1884, was widely copied. An early chronicler of concrete construction wrote,

It is mainly due to Ransome's missionary work that reinforced concrete construction has reached its present (1906) commanding position in building construction. Through communications to the technical press, the reading of papers before engineering societies, lecturing before architects and engineers, he kept up an active propaganda on the subject and paved the way for the widespread introduction of this new form on construction.¹⁰⁴

His work helped put San Francisco in the forefront of concrete building construction at the turn of the century. Thus, there happened to be more buildings with concrete floors in San Francisco at the time of the 1906 earthquake than in any other American city.

In the 1880s, imports of Portland cement increased considerably and prices fell; in the latter half of the 1890s, domestic production began on a phenomenally sharp upward trend. The price of a barrel for American Portland cement fell from \$3 in 1880 to about \$2 in 1890, and then to a little over \$1 in 1900.¹⁰⁵ Moreover, much technical work on formulation and manufacture of concrete for building had occurred in Europe, notably in France.

In the second half of the 1890s, concrete began to be introduced in fireproof buildings to a large extent in the U.S.; it was less expensive than tile. Concrete was used for constructing floors and partitions, and for column fireproofing, in skeleton frame buildings. It began to be used for constructing entire buildings -- beams, walls, and roofs. The systems of concrete floors used in skeleton frame buildings generally consisted of wire cloth or rods embedded in the lower part of a concrete slab. Most were built in the same way: wood form-work was set up, reinforcing was put in place, and concrete was poured. The systems were made by many companies and the differences mainly were in the design of the reinforcing fabric. Some systems were patented, but the basic reinforced floor, with wire lath for example, could be built by anyone. (Illustration 6-6.)

Concrete was also used in the form of an arch. One type that was widely used on the East coast was the Roebling arch, which was made over a wire centering. The centering was left in place, thereby removing the need for wood form work. Plain concrete arches, not

¹⁰⁴ Walter Mueller, "Reinforced Concrete Construction," p. 66.

¹⁰⁵ Robert Lesley, History of the Portland Cement Industry in the United States (New York: Arno Press, 1972).

Illustration 6-6. Concrete floors. Top, slab with metal lath (wavy line); bottom, Roebling arch.

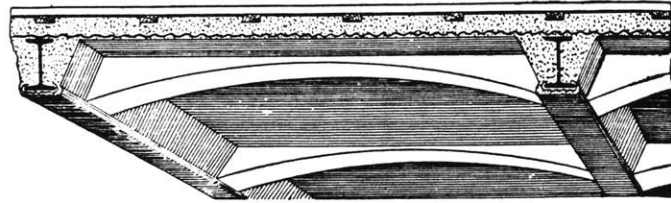


FIG. 62.—Expanded-metal Concrete Floor—Arched System.

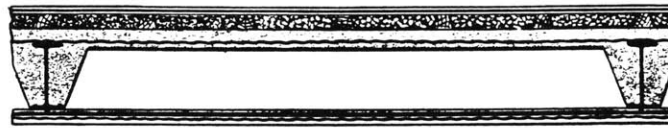


FIG. 63.—Expanded-metal Concrete Floor with Suspended Ceiling.

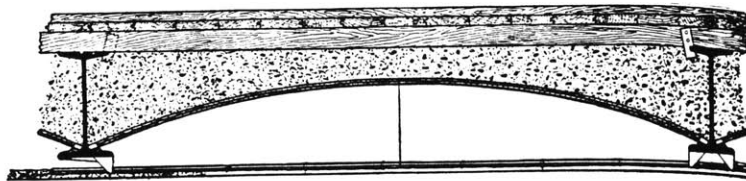


FIG. 60.—Roebling Concrete Arch, with Suspended Ceiling.

subject to patents, were built in the kinds of situations where segmental hollow tile arches might have been used, e.g., warehouses. Dispensing with form-work was a great desideratum, and various metal fabrics and form-works were introduced to accomplish this for flat floors as well arched ones. However, the drawback to them at the time was the difficulty of protecting the metal underneath from fire.

Concrete systems, as they evolved, had several advantages over hollow tile. Concrete floors could be lighter, resulting in a savings in iron and steel framework, were better adapted to irregularly shaped floors, and could form a smooth surface, without breaks or joints, as is tile. On the other hand, concrete floors required much water at the job site; they took longer

to dry out than tile floors and the workmen had to be supervised closely.¹⁰⁶ Even the lightness of concrete floors was considered a disadvantage by some. Edward Shankland, a civil engineer who worked on tall buildings in Chicago, felt as of 1898 that concrete floors lacked the lateral stiffness of hollow tile floors.¹⁰⁷ The main selling point of concrete floors was that, in the latter part 1890s when they began to be built to a large extent, they cost less than hollow tile systems. An important factor in the cost difference was that they could be built with unskilled laborers rather than the skilled masons who set the tile floors. This difference was emphasized by the advocates of concrete and was a reason union masons opposed concrete.¹⁰⁸

Concrete builders had hardly entered the market, in the early 1890s, when the tile manufacturers and their supporters went to war against the upstart competitors. One of the strongest arguments against concrete (because, unlike the question of strength, it was hard to prove) was that concrete was not really fire-resisting and would not hold up in a fire. In an unsigned article in Architectural Record, the author claimed that "exhaustive tests" had shown that fire of ordinary intensity will ruin concrete. The only reason for even discussing the subject, the article explained, was the "aggressive advertising" of the concrete builders on the "strength of a specious fire-test conducted under the auspices of the New York Building Department" in late 1897. The writer did not trouble the reader with details of any of the tests of concrete, but did provide information on tests of tile arches.¹⁰⁹

Such an aggressive advertisement appeared in that very same volume Architectural Record, for the firm John A. Roebling's Sons Co. Roebling Fire-Proof Flooring was a

¹⁰⁶ Thomas Nolan, Kidder's Pocket-Book, 16th edition, p. 829.

¹⁰⁷ Edward Shankland, "Steel Skeleton Construction in Chicago," pp. 56-57.

¹⁰⁸ The Bricklayer's Union in New York City opposed amendments to the city's building law that would have allowed concrete floors because they feared a loss of work for bricklayers would result. Testimony of John J. Donnelly, business agent for Bricklayer's Union No. 7 in "Report of the Special Committee, Appointed to Investigate the Public Offices and Departments of the City of New York," (Mazet Committee), 1900.

¹⁰⁹ "Burnt Clay Fireproofing and Its Substitutes," Architectural Record vol. 8 (July-Sept., 1898), pp. 111-116.

construction venture of the well-known Roebling engineering and wire manufacturing company, which had commenced operations in the early 1890s. The early form of concrete floor consisted of wire rods crisscrossed over the top of beams, covered with concrete; a ceiling of plaster on wire was suspended under the floor. A trade circular mentioned that the strength of concrete had been demonstrated in tests by Kirkaldy, Hyatt, and Ransome, and factors for the compressive strength of concrete had been determined with the U.S. testing machine at Watertown.¹¹⁰ The company's ad in Architectural Record pointed out that tile floor arches invariably settle over time and may crack, while a segmental concrete arch as illustrated in the ad "never settles" because it was monolithic.

That this competition became so bitter even though concrete construction was in its infancy is somewhat surprising. With fireproof construction expanding, one would think that there would have been contracts enough to keep everyone busy. The concern about the reliability of concrete was undoubtedly genuine: Americans had had little experience with concrete in buildings. Not only was the material not uniform, but how it is made at the job site also varied. But the great challenge of concrete to established material manufacturers was its cheapness, and the vehemence of the opponents also suggests a premonition as to which product would dominate the fireproof floor market.

New York was the largest market for building materials and the manufactures of the new concrete floors systems all were trying to introduce their floors there. However, the concrete floors systems were not allowed in New York under the codes of the day, although they might be built with permission. The lack of information about the systems led the Superintendent of Buildings to test various concrete, and tile and concrete, floor systems, eleven in all, in 1896. The concrete floors tested were: a Roebling arch; Thomson concrete slab with small I beams; a Columbian floor, made of cross-shaped steel bars in a concrete slab; Bailey floor, which was concrete on a sheets of metal in a dovetail shape; Clinton Wire-cloth, Manhattan, Expanded Metal Co., and Metropolitan, these last four all variations of wire fabric in a concrete slab. The tests were very severe and although all the floors were

¹¹⁰ The Roebling Fire-Proof Flooring, c. 1890, trade catalogue, collection of the Hagley Museum and Library.

damaged to some extent, the general conclusion is that concrete had proved itself to be a satisfactory material for fireproof floors. After further tests conducted by the manufacturers of concrete floor systems for the Building Department, the Department withdrew its prohibition. Then the administration of the city changed and the new Building Commissioner objected to the systems.¹¹¹ Thus, the manufacturers of concrete systems joined to lobby a committee working on a revision to the city's building code to allow their products as of right in New York.

Advocates of concrete got help, in a sense, from a conflagration in Pittsburgh in May, 1897. This fire was much studied by architects and engineers because it involved several fireproof buildings, including one, the Methodist Building, with concrete slab floors. The two other fireproof buildings involved in the fire have hollow tile floors covered with a thick layer of concrete. This fire provided data on the fire resistance of concrete. Even among professionals, the interpretation of the data seemed to be shaded by biases towards or against concrete. The indisputable fact was that the Methodist Building, structurally, was little damaged in the fire while the contents of the building had been consumed. Corydon Purdy, the respected structural engineer, concluded in a paper read to the A.S.C.E. that the Methodist Building had not been as intensely exposed as had the two other fireproof buildings, which suffered more damage. Therefore the relative value of the systems had not been properly tested. But in the discussion following his paper, engineers who had inspected the buildings for the insurance adjusters disagreed with Purdy's conclusion. The Methodist, in their opinion, had been exposed to intense heat and had withstood it well, a result that was consistent with the New York City tests. They concluded that "properly made concrete was as good if not better than burnt clay."¹¹²

The fight between the tile and concrete camps took an odd turn in New York City,

¹¹¹ William Tubby testimony, Report of the Special Committee of the Assembly, Appointed to Investigate the Public Offices and Departments of the City of New York..., January 15, 1900. This report will be referred to subsequently as the Mazet Committee Report, 1900.

¹¹² Corydon Purdy, "Can Buildings be Made Fireproof?." A.S.C.E. Transactions vol. 39 (June, 1898), p. 141, quote p. 159.

when the topic of floor construction was vigorously pursued by a committee of the state assembly established in 1899 to investigate abuses of official power New York City. The committee, called the Mazet Committee after its chairman, Robert Mazet, was created to harass New York's Democratic political boss, Robert Croker, and was viewed as such in the press at the time. It was "a device of one set of political corruptionists to extort, by a pretence of exposure, from another set of corruptionists, a larger share than it now enjoys in the plunder of the great city of New York."¹¹³ The Building Department was one of the city departments investigated, and the committee seemed bent on smoking out the conspiracy to allow concrete floors to be built in New York City.

The main protagonist in the concrete floor drama was the Roebling Construction Co. This company had been formed at the end of the decade to carry on the fireproof construction work formerly done by John A. Roebling's Sons Co. One of the investors in the new company was Frank Croker, one of Richard's sons.¹¹⁴ Moreover, a nephew of Croker represented the Roebling Co. in petitions to the Building Department.¹¹⁵ The majority members of the Mazet Committee apparently hoped to show that exceptions were granted, and specifications for the construction of city buildings were changed, so as to benefit the company in which Croker, or at any rate, his son, had an interest. Essentially, the committee tried argue that the Building Department was acting corruptly when it allowed concrete floors to be built in New York, which would only follow logically if there was something wrong with concrete floors. The whole effort was futile: concrete was not a bad system merely because Richard Croker's son was involved in one of the companies that made concrete floors. While concrete floors were allowed with approval at this time, the right to use concrete unconditionally awaited the 1903 revision of the building law.

The systems listed are only representatives of the great variety of products in what was at the turn of the century beginning to be called the "fireproofing" industry. As the

¹¹³ AABN vol. 64 (April 15, 1899), p. 17.

¹¹⁴ Abraham Himmelwright, manager of the Roebling Construction Co., testimony, Mazet Committee Report, 1900.

¹¹⁵ Charles McCann testimony, Mazet Committee Report, 1900, p. 87.

builder Henry Ericsson remembered this time of great innovation in the building industry, "It is quite impossible to convey in the space at my command a full review of the ranges and diversities of materials and creations which the rising technology had flooded the building industry in the closing decades of the nineteenth century."¹¹⁶ Competition drove down prices, which further encouraged owners to opt for fireproof construction. Why, if economic trends were in the direction of making fireproofing products more affordable, and therefore more likely to be adopted by owners -- apart from the high buildings, in which they were inevitably adopted -- was it necessary for building codes to continue to require fireproof construction, indeed to become more strict and specific as to requirements? The reason was that the level of safety required for the community exceeded what most owners needed for their own purposes, and therefore they would be inclined to under-invest in the building. Column protection could be secure or flimsy, the former costing more than the latter, but an owner could get no more rent for using the best fireproofing. Most owners would do the right thing only if they were forced to do so, which they were as building codes in cities across the nation became more detailed.

The Underwriters and the Fireproof Building

Contrary to what might be expected, the stock fire insurance industry did little to encourage fireproof construction through most of the nineteenth century. A large share of the industry believed that the industry itself had no obligation to work to improve the character to the nation's buildings; the industry's job was to insure buildings as it found them. This may sound like a philosophical principle, but it had practical roots.

To understand the seemingly paradoxical charges against the industry -- that it was indifferent to the quality of construction and that it actually made cities less safe by encouraging owners to act irresponsibly -- it is necessary to know two important facts about the industry in the nineteenth century. First, the industry was virtually a perfect market, with all the attendant advantages and disadvantages. The costs of entering the business were small: no expensive equipment, facilities, licenses, stock, or even special knowledge were required. This permitted fly-by-night companies to set up. Leaving aside the invitation to

¹¹⁶ Henry Ericsson, Sixty Years a Builder, pp. 226-227.

dishonesty, this situation led to wide swings in profitability, buffeted by economic conditions and competition -- a state of unpredictability that many insurance companies abhorred.

For this reason, a segment of the industry supported state regulation of the industry. The first form of state control was licensing and taxation aimed at excluding out-of-state companies.¹¹⁷ Such policies, of course, was counterproductive. A company with risks concentrated in only a few places was more likely to fail if any of the places suffered a conflagration.

One reason some in the industry accepted buildings of varying conditions is that worse risks paid higher rates of premiums. Most insurance was sold by agents who worked on commission -- a percentage of premiums -- and who therefore earned more when premiums were higher. It may seem that the interests of local agents therefore were potentially at odds with those of the insurance companies they represented. This conflict was alleged by the Factory Mutual officials, who did not use agents. John R. Freeman, for example, suggested that stock companies were finding that the agent's unwritten maxim that bad risks give good commissions was bad business policy.¹¹⁸

This system could persist because of the crude way that rates were set, which was on the basis of the type of construction and occupancy, or competition. Insurance companies might charge more than the rate for a particular category for features of a building considered especially hazardous, but rarely gave discounts for buildings that were better than average.¹¹⁹ Even if such discounts had been offered, they would have had little effect on

¹¹⁷ Jacob Cardozo, a Charleston businessman, recalled that the South Carolina legislature taxed foreign and northern insurance companies to discourage them from doing business in the state, to the disadvantage of consumers. (Reminiscences of Charleston (Charleston: J. Walker, 1866)).

¹¹⁸ John Freeman, "Comparison of English and American Types of Factory Construction," Journal of the Association of Engineering Societies, remarks presented Sept. 17, 1890.

¹¹⁹ For example, Continental Insurance Company of New York was one company that was willing to give breaks for safer construction. In his pamphlet on Economical Fire-Resisting Construction, Continental's President Francis C. Moore described several systems of fire-resisting construction and wrote that he would "write double the ordinary line [of insurance], at one-third less rate" on a fire-resisting building compared with an ordinary one, and urged his fellow underwriters to do the same. "If like encouragement were given by all

the development of fireproof construction, since insurance savings could not approach the extra cost of building fireproof. Improving rate setting, to price relative risk more accurately, required gathering much information, a costly process. Loss statistics "in the general fire insurance field ... were guarded jealously by the individual companies as private trade secrets."¹²⁰ The National Association of Fire Engineers sent a memorial to Congress in 1884 requesting that the government collect fire statistics, but Congress decided that fire matters were local.¹²¹

The pages of AABN were regularly berated the insurance industry, on the one hand, for failing to reduce the premiums on buildings where owners had invested in fire protection and, on the other, for making cities less safe by insuring bad risks. The following editorial is characteristic: AABN is commenting on an 1887 editorial in the fire fighter's magazine, Fire and Water, in which underwriters were charged with contributing to the heavy fire losses in that year,

The insurance companies, while they insure these (hazardous) structures at rates which they know to be inadequate to the risk, and with a pretence at inspecting them to see if they cannot be made a little less dangerous, take advantage of the ignorance of the public in such matters to charge enormously profitable rates on the better risks, so as to bring the average up to a remunerative rate. ... As we have often said, if the underwriters cannot protect themselves against losses by inflammable construction, no one else can do so.¹²²

In fact, someone else could protect the underwriters, and that was the community as a whole through its building codes. For this reason, underwriters had long worked for stronger building laws to avert what they most feared, which was conflagration. Individual building fires, cynics charged, were good for business, because they encouraged people to buy

underwriters -- and it seems to me they could safely afford it -- we might expect to find our cities better constructed and the 'conflagration' hazard materially reduced. (F. C. Moore, Economical Fire-Resisting Construction revised edition, May 1892, p. 13.) But Moore was the leader in the movement to develop schedule rating, and the practices of his company undoubtedly were not the norm.

¹²⁰ Dane Yorke, Able Men of Boston, p. 114.

¹²¹ Clifford Thomson, "The Waste by Fire," The Forum vol. 2 (1886), pp. 27-39.

¹²² AABN vol. 22 (Aug. 20, 1887), p. 81.

insurance. Conflagrations, and the enormous, sudden liabilities they created for companies, were not. The conflagration in Portland, Maine in 1866, sparked the founding of the National Board of Fire Underwriters (now the American Insurance Association), which became the main national trade association for the stock insurance industry. Formed initially to establish uniform rates of premium and compensation of agents, and to prevent arson, it took up the cause of fire protection after the Chicago and Boston fires. The new theme was sounded in NBFU President Henry Oakley's annual address in 1873, when he called for local government to pass laws requiring fire resistant construction. He noted that New York City had a building law, but it was "administered feebly" and Boston's building law, passed after the Chicago fire, was inadequate. He urged the NBFU to "shape legislation that will benefit not only our own interests but the whole country, by securing such wise and salutary laws as might prevent the recurrence of other destructive conflagrations."¹²³

Nevertheless, a forward-looking segment in the industry was beginning to accept that more could be done through rate setting to improve buildings so as to reduce fire loss and, incidentally, improve public safety. Some underwriters acknowledged the industry's ambivalence toward better construction. An 1880 report by the Committee on the Construction of Buildings of the National Board of Fire Underwriters wrote that,

insurance companies might ... say that it is not their province to trouble about the character of buildings which may be erected, except for the purpose of ascertaining for themselves the extra risk hazarded where bad construction prevails, with a view of making extra charges....

But while this view might be "defended from a business point of view, and we have heard of its advocacy by companies of respectable standing," it showed a low estimation of the practice of underwriting. Rather, work should continue in developing statistical information until "an approximately correct basis shall be reached in respect to the price of insurance."¹²⁴ In other words, the industry could have a beneficial effect -- help reduce fire loss overall -- by setting rates more accurately. The industry worked on both fronts: to get

¹²³ Quoted in A. L. Todd, A Spark Lighted in Portland; the Record of the National Board of Fire Underwriters (New York: McGraw-Hill Book Co., 1966), p. 26.

¹²⁴ Extracts of a report printed in AABN vol. 8 (Aug. 28, 1880), p. 104.

building laws passed that would have the effect of reducing conflagration, and toward setting rates on a more objective basis.

The regional and national insurance trade associations supported the passage of building codes and their representatives served on code writing committees, in order to achieve limits on restrict heights and volumes of buildings through law, which they would or could not achieve through rates. And they were successful in achieving these limitations. For example, a Massachusetts law of 1891 restricted the height of buildings in all cities in the state to 125 feet.¹²⁵ In another big year for codes revisions, 1892, Boston, Chicago, and New York all passed new, technically advanced building laws. Boston's 1892 law put a definite 125-foot limit on building height and dropped the threshold for fireproof construction 10 feet, to 70 feet, and required that large hotels, as well as theaters, also be fireproof. It restricted the clear floor area of non-fireproof buildings to 10,000 square feet.¹²⁶ (In the next year, the act was amended to reduce the undivided area of non-fireproof buildings to 8,000 square feet.¹²⁷) In Chicago, the fire insurance underwriters continued to want height limitations and they had support in the City Council there.¹²⁸ Eventually limits were adopted in many cities, but with a few exceptions, these regulations were not really restrictive at all since the limits exceeded what any owner would have wished to build.¹²⁹

At the same time, a committee of underwriters were working to develop a rating system that would more accurately reflect the risk inherent in a particular property. A committee of underwriters, led by Francis C. Moore, President of the Continental Insurance

¹²⁵ Chapter 355 of the Acts of 1891.

¹²⁶ Chapter 419 of the Acts of 1892.

¹²⁷ Chapter 464 of the Acts of 1893.

¹²⁸ Chicago correspondent, AABN vol. 23 (March 24, 1888), p. 136.

¹²⁹ In 1913, many U.S. cities had height limits on the books, however only in Boston, Chicago, and Washington, DC, did many buildings approach the maximum. "The maximum height limit is no height limit at all so far as most buildings are concerned; it only prevents the erection of a few exceptionally high buildings." Report of the Heights of Buildings Commission, Board of Estimate and Apportionment of the City of New York, Dec. 23, 1913, p. 22.

Co., began work in the early 1890s to develop a new system of rating, called "schedule rating." Unlike the broad categories of the past, within which all buildings were treated the same, this system was designed to distinguish among buildings within categories and to explicitly list all the factors that should go in to setting a rate. The result of the committee's efforts, was an elaborate system called the "Universal Mercantile Schedule." It followed the approach of the Factory Mutuals in that it established a "standard" city and a "standard" building, and made these standards high. But whereas the AFM companies might reject buildings that did not meet their standards, the stock companies charged higher rates for buildings that departed from the standard. What was more unusual was that the schedule allowed for deductions for exceptional features that made individual buildings exceed the standard. The declared object was to increase the quality of construction, according to the Committee,

While the requirements for standard construction in the schedule may be regarded as exceptionally high, and while there are few buildings which comply with them, it will be conceded that there ought to be more, and the compilers (of the schedule) believe that the best way to secure their erection is to recognize, in advance, the merits of ideal construction.¹³⁰

The schedule was published and was intended to be educational, to explain to property owners the underwriters' ideas on safe construction. In cities where the schedule was used by the local underwriters, owners could select the rate of insurance they wanted by seeing the price for all items. Of course, the fact that underwriters in an area adopted the schedule did not mean that all companies charged the same price. The Committee recommended, rather, that companies offer "discounts" from the set prices, but maintain the schedule because it was necessary to gauge the relative risk of characteristics of buildings. Although the principle was sound, there still was no reliable, broad-based information on which to price items in the schedule. General fire and loss statistics came later, in the early twentieth century, and schedule rating (the Universal or the Dean (Analytic) Schedule became the underwriting

¹³⁰ "Standard Universal Schedule for Rating Mercantile Risks," in Francis C. Moore, Fire Insurance and How to Build (New York: Baker & Taylor Co., 1903), p. 624.

system of the fire insurance industry.¹³¹ As the name of the schedule suggests, it applied to commercial buildings. A separate schedule was developed for manufacturing and for fireproof buildings, and other schedule rating systems were devised later.

This schedule was an important step forward in making the industry rational and therefore was good for the industry, but it was prompted partly to head off government regulation. Insurance companies were chartered and regulated by the states in which they were domiciled; however, many operated across state boundaries. The question of whether the state regulations were interfering with inter-state commerce was decided in 1869, when the U.S. Supreme Court ruled that an insurance policy "was not a transaction in 'commerce,' in the constitutional sense, and hence not under Congressional control."¹³² The practical effect of this illogical ruling is that states were allowed to continue, and indeed given the responsibility of regulating, companies that did national business.

Some states, for example Massachusetts, had volumes of legislation governing insurance companies, regulating what kinds of investments they could make and the liability of stockholders. The main purpose of the early regulation in the nation, besides taxation and protection of state-based companies from "foreign" (meaning out-of-state) competition, was to assure solvency of companies, although it could hardly be very effective in this respect. Nevertheless, control in this regard was welcomed by the larger companies, who considered the fly-by-night and wildcat companies threats to an orderly and sound industry. In the 1850s, underwriters in Massachusetts and New York supported creation of state departments to supervise the industry, specifically to try to weed out the weak and dishonest companies. Other states began to establish similar regulatory bodies.¹³³

Another issue arose later in the century that state insurance departments were called on to handle: the fairness of industry-set rates. To be accurate, rates had to be based on the

¹³¹ Laurence Ackerman, "Principles of Fire Insurance," in N.F.P.A., Fire Protection Engineering (Boston: N.F.P.A., 1943).

¹³² The Economics and Principals of Insurance Supervision (Madison: University of Wisconsin, 1960), p. 5.

¹³³ H. Roger Grant, Insurance Reform: Consumer Action in the Progressive Era (Ames, Iowa: Iowa State University Press, 1979), p. 5 and 71.

experience of a large group of properties, more than those insured by any one company. One of the main purposes of local insurance trade associations was to eliminate disruptive competition. These trades associations, with names like New England Insurance Exchange, Underwriters' Association of New York State, Southeastern Tariff Association, supported rating bureaus, which provided the associations with inspection and rate making services. The trade associations then tried to get members to adhere to the supposedly objectively determined rates. The rates were for cities, counties, and states. Apparently in some areas, the trade associations had success in enforcing their rates. However, the public in many states began to complain that rates were excessive and inequitable, and resulting in inflating profits to the companies. State-level "anti-trust" legislation began to be introduced at the end of the 1880s in the Mid-western states, at any rate, to outlaw the collaboration on rates and rating bureaus, and a movement against rating bureaus continued in the next decade.¹³⁴ Presumably it was in part to head off regulation they did not want that the committee of underwriters met to try to develop a national schedule, based on objective criteria.

Some underwriters advocated "insurance control" as an effective means to improve the safety of cities, although they did not suggest that cities should abandon codes. But others pointed out that since carrying insurance was optional, laws governing construction would always be necessary,

It is desirable that any rules upon which depend the security, not of individuals, but of a whole city, should be of universal application and supported by an authority that reaches everybody. There is no such authority except the law. There will always be persons who will prefer to run risks rather than pay for insurance; there will be others who will prefer an indulgent company to a strict one.... It is necessary, nevertheless, to protect men from their neighbors, and this is exclusively the function of the law.¹³⁵

At any rate, the tendency of the early twentieth century was toward more advanced bases for underwriting and better building codes. The new rating schedules, especially the more favorable treatment eventually given to fireproof buildings, must have helped tip the scales in favor of fireproof construction.

¹³⁴ H. Roger Grant, Insurance Reform, chapter 4.

¹³⁵ AABN vol. 7 (January 31, 1880), pp. 33-34.

Triumph: Fireproof Skyscrapers Survive Conflagrations

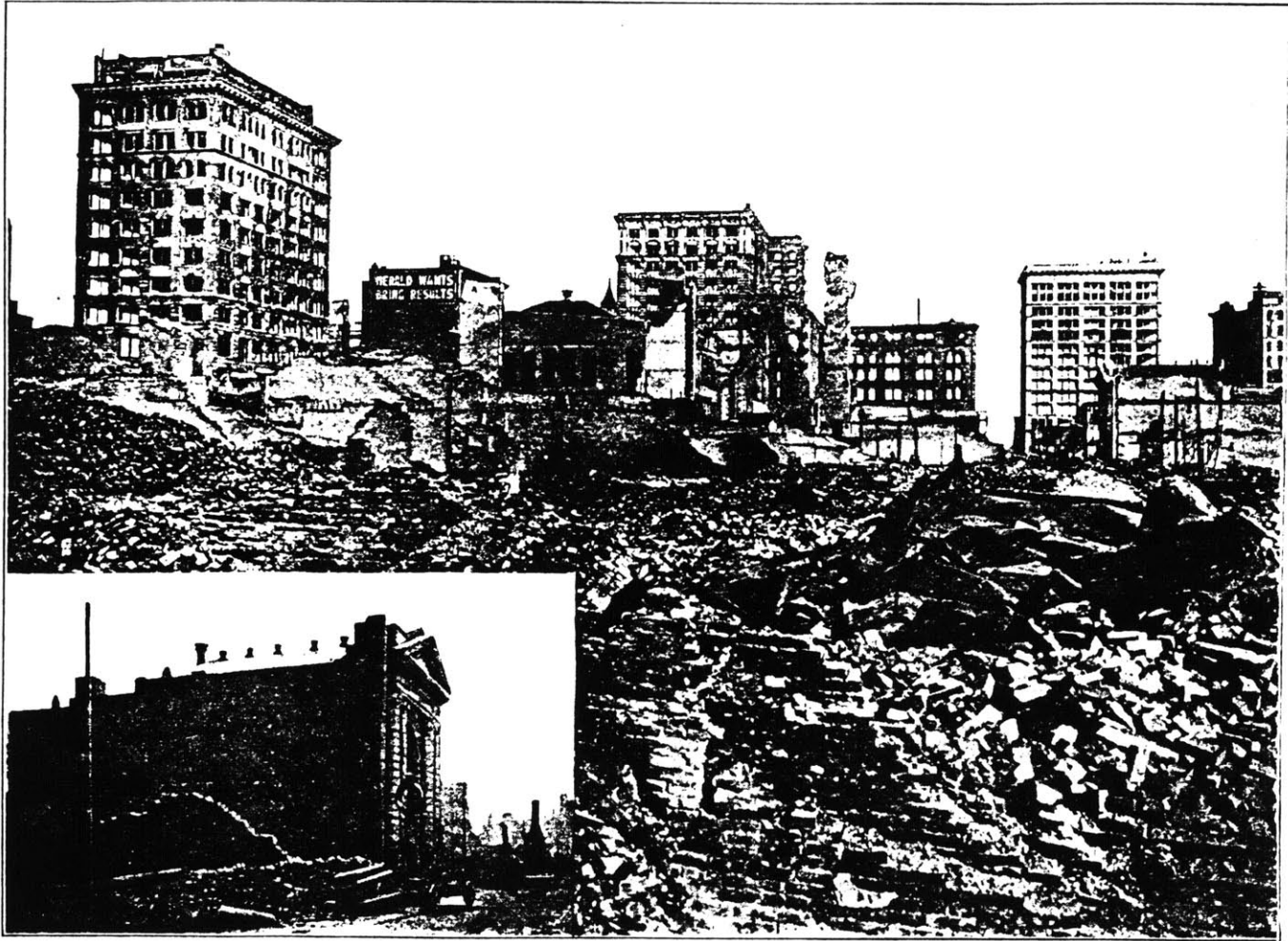
On a Sunday morning, February 7, 1904, a fire that started in the basement of a dry goods store in Baltimore swept up an elevator shaft and ignited the upper floors of the building, causing a series of explosions. Firemen were at the scene five minutes after the first alarm sounded, but already the surrounding buildings were burning out of control. Soon the downtown was engulfed in flames. The fire department tried to create fire breaks by blowing up buildings, which only spread the fire. The fire burned until the evening of the following day when it was finally stopped by natural and manmade barriers, which included, on the north, a wall of substantial public buildings guarded by phalanxes of local firemen as well as companies from Philadelphia, New York, Washington, Wilmington, and York, Pennsylvania, and the powerful fire tug, the Cataract. In all, about 2,500 buildings, on 140 acres of land, were burned.

This was not the first great conflagration of the new century -- that dubious honor already was claimed by Jacksonville, Florida in 1901. But unlike jerry-built Jacksonville, Baltimore was a substantial city. It contained perhaps a dozen modern style fireproof buildings. Thus, the Baltimore fire was the first test of the latest generation of fireproof construction methods under conflagration conditions. For this reason, fire experts, architects, civil engineers, and builders converged on Baltimore to study the consequences of the fire and especially the performance of the fireproof buildings. What would this fire show about the modern methods of structural fire protection?

To the uninitiated, the verdict was not good. The ordinary building were heaps of rubble and the fireproof buildings were standing. But the fireproof buildings were all more or less damaged. (Illustration 6-7.) The utter devastation of the city seemed to suggest that the whole idea of "fireproof" construction was a sham. How, journalists asked, could buildings purported to be fireproof be damaged by fire? Were these buildings just expensive fakes? Some fire insurance underwriters joined the chorus of critics. The Baltimore fire, said one, "shows that modern fireproof buildings will not even retard a great conflagration," while another warned owners not to expect to save on insurance by building fireproof, declaring, "It

is time for those who have been complaining about rates to take a back seat."¹³⁶ A few fire protection experts believed the Baltimore fire exposed that the term fireproof was misleading. Now it was Edward Atkinson's turn to gloat, "the first lesson taught by this conflagration is for the underwriter to expunge the term 'fire-proof' from his dictionary."¹³⁷

Illustration 6-7. Baltimore after the 1904 conflagration, with fireproof buildings standing.



The consensus of opinion among the experts, on the other hand, was that Baltimore's

¹³⁶ New York Times, February 9, 1904, p. 3.

¹³⁷ Introduction to "The Conflagration in Baltimore," report no. 13, Insurance Engineering Experiment Station, Boston, Mass., Jan., 1904.

fireproof buildings had performed well.¹³⁸ The fire had gathered fury while it burned through several blocks of non-fireproof buildings before it reached the fireproof buildings. In the wreckage of the fireproof buildings, investigators found melted glass and cast iron, which melt at about 1650-1700 degrees.¹³⁹ Yet Baltimore's "fireproofs" obviously were standing, while the great majority of non-fireproof buildings were not. The damage they suffered, the experts believed, was attributable to imperfect planning and shoddy construction in some cases and to the fact that the buildings generally lacked defenses against exposure fire. These defects could be corrected with existing methods and materials. The solution to the fire problem was not to go back to the old "brick and mortar" system, but to build more fireproof buildings, as an editorial in Engineering News explained,

The experience of Baltimore has illustrated afresh what every well-informed engineer already grasps, but what the general public is slow to grasp, that no human ingenuity can devise a building of reasonable cost and utility which will withstand unimpaired the attacks of such a conflagration as raged last week in Baltimore. On the other hand, if all buildings in the business section of a city were reasonably fire-resistant, as they might be at moderate cost, large areas could not be fire-swept and utterly destroyed.¹⁴⁰

In other words, fireproof buildings could help avert conflagration, but only when most of the buildings in a city are fireproof.

Edward Atkinson was of the opinion that the Baltimore fire taught nothing that was not already known, and in a sense, the majority of experts would agree. But one controversy still was not laid to rest to the satisfaction of all, and that was the fire resistance of concrete. With reference to the few, small buildings in Baltimore with concrete floors, a report of the National Fire Protection Association concluded that the heat in the buildings had not been great enough to test the material.¹⁴¹ Many others concluded that the concrete had indeed

¹³⁸ "Detailed Studies of Fireproof Buildings in the Baltimore Conflagration," Engineering News vol. 51 (Feb. 25, 1904), pp. 169-173; Joseph K. Freitag, Fireproof vol. 8 (1906), p. 174.

¹³⁹ John R. Freeman, "An Engineer's Suggestions to Fire Underwriters," address at the annual banquet of the National Board of Fire Underwriters, May 12, 1904.

¹⁴⁰ Engineering News vol. 51 (Feb. 18, 1904), p. 153.

¹⁴¹ Quoted in J. K. Freitag, Fire Prevention and Fire Protection, p. 176.

proved to be superior to tile. Charles Ladd Norton, head of the Factory Mutual's Insurance Engineering Experiment Station, wrote that this fire, plus his own recent examinations of concrete, convinced him that concrete could withstand such a fire with little damage, while tile could not.¹⁴² Likewise, the engineer Carl Greishaber, concluded that concrete floors withstood the fire best.¹⁴³

Two years later, in April, 1906, San Francisco burned in a conflagration that followed the great earthquake. Four square miles of the city burned, the business center as well as entirely wood-frame, residential areas. No civilians were killed in the Baltimore fire, but hundreds of people perished in San Francisco. Today people recall the earthquake, but at the time, the engrossing event was the fire. After the earthquake, some fires had broken out; people also started fires by trying to cook in houses with broken chimneys. Fires started in several locations. The city's water mains broke in the earthquake, so the fires could not be fought. Even before the earthquake, a report on the fire safety situation of the city by the National Board of Fire Underwriters concluded that the city was ripe for conflagration.

Perhaps because of the conflagration hazard, many of the buildings in the commercial center were -- over 50 -- were fire-resisting. Many of the buildings were new and some were under construction at the time of the fire.¹⁴⁴ What was unique about San Francisco's buildings is that the vast majority had concrete floors. Concrete had been used on the Pacific coast to a large extent, encouraged presumably by the work of Ransome and Hyatt's popular illuminated sidewalk panels. No other city had so many buildings with concrete floors; in no other place could concrete have been put to such a test. But the fact that buildings may have been already damaged by earthquake, and also that many buildings in San Francisco and surrounding area were poorly designed and badly built, made this a less than perfect test.

Many detailed studies of San Francisco's fireproof buildings appeared after the fire. One of these was conducted by several prominent engineers for the U.S. Geological Survey.

¹⁴² Charles Ladd Norton, "The Conflagration in Baltimore," pp. 10-11.

¹⁴³ "Detailed Studies of Fireproof Buildings in the Baltimore Conflagration," Engineering News (vol. 51), p. 173.

¹⁴⁴ J. K. Freitag, Fire Prevention and Fire Protection, p. 180.

The four engineers prepared separate reports and their conclusions seemed contradictory.

Richard Humphrey of the U.S.G.S., concluded,

Concrete, especially reenforced concrete, because of its great adhesive strength and reenforcing metal, proved more satisfactory than any other material. ... Cinder concrete was used extensively for floors and elsewhere and was of a very inferior grade. ... If reenforced concrete of the quality described could give such satisfactory results in meeting the extraordinary condition of the San Francisco earthquake and fire, it is evident that much greater satisfaction would have been given by the use of first-class material.¹⁴⁵

John Sewell, Captain in the Corps of Engineers was less impressed with the performance of concrete, and actually recommended that concrete floors be fireproofed with plaster! The concrete skeptic and fire protection authority, Joseph K. Freitag, summarized all the knowledge about concrete in his comprehensive textbook on fire protection, was unable to make an unequivocal statement respecting what he called "the old and vexed question of concrete vs. terra-cotta construction."¹⁴⁶

Nevertheless, the market spoke, and it voted for concrete. Henry Ericsson recalled that in the first decade of the century, reinforced concrete was "coming in" Chicago. Architects there were initially reluctant to use it, "but back of the cement and steel manufacturers there was a tremendous driving power that in time swept the architects along, resulting in the use of reinforced concrete even where it was of doubtful economy or value."¹⁴⁷ Likewise in Philadelphia, a variety of concrete floors were built in fireproof buildings. In Baltimore, 90 percent of the new fireproof buildings used concrete either in floors or in column protection, or both.¹⁴⁸ The last important ingredient in commercial construction was accepted, and eventually spread to buildings of all sorts.

¹⁴⁵ G. K. Gilbert, et al., The San Francisco Earthquake and Fire of April 18, 1906, bulletin no. 324, Department of Interior, U.S.G.S., 1907, p. 58.

¹⁴⁶ J. K. Freitag, Fire Protection and Fire Prevention, p. 181.

¹⁴⁷ Henry Ericsson, Sixty Years a Builder, p. 282.

¹⁴⁸ Fireproof vol. 8 (1906), p. 39.

Chapter 7.

Calamity: the Need for Attention to Life Safety

Introduction

The objects of structural fire protection, as defined in the first comprehensive textbook on fire prevention and fire protection, were "control of fire through construction, control by means of first aid or departmental work, detection of fire by automatic means, and safety against exposure fire."¹ Missing from this definition is any mention of safety to human beings.

If building laws were necessary to compel owners to make their buildings more fire resisting -- property in which they actually had an interest -- they were doubly necessary to make owners provide adequate egress. Apart from the natural tendency to skimp on safety, people object to the idea of devoting space in a building to something so unprofitable as exits. Egress facilities were a pure cost with practically no compensating aspects. In the nineteenth century, adequate egress was not even necessary to forestall lawsuits, since a building owner had no liability for deaths and injuries due to accidental fires on his premises. As with building laws generally, the purpose of egress provisions was not to protect the owner but to protect the public, the users of the building or unsophisticated buyers of a building, from an owner's disinclination to install safeguards.

Emergency egress was considered a problem for certain kinds of buildings notably places of public assembly -- e.g., theaters and halls -- and buildings in which many people lived or worked, such as tenements, hotels, and factories. Except for theaters, these were not the kinds of buildings that were thoroughly fireproof. Theaters were the only kind in which both the provisions for egress and the methods of construction were strictly regulated in some cities. The only other kind of building required by law to be fireproof was the tall building, and only in the fairly rare case where a tall building was used for certain purposes were they required to have more than minimal egress facilities. For example, in New York, a 16 story

¹ Joseph K. Freitag, Fire Prevention and Fire Protection as Applied to Building Construction 2nd revised edition (New York: John Wiley & Sons, Inc., 1921), p. 33.

hotel would have to comply with the fireproof construction requirements and the egress requirements for hotels. There were no special egress requirements for buildings because they were tall.

The reason for this is that the great majority of tall buildings were used for offices or warehousing and as such were considered at low risk for fires. Moreover, a fireproof building was believed to be inherently safer for the occupants, who presumably had only to leave the burning floor to be protected. In the great scheme of concerns of the structural fire protection experts who helped develop the fireproof building, emergency egress ranked low.

As the history of egress laws shows, the adequacy of egress, like so many lessons in the field of fire safety, was learned the hard way. Following several deadly fires in fireproof buildings, the matter of egress began to receive thorough study by the fire protection field. By this time, methods of structural fire protection had advanced to the point where buildings could be constructed that were, practically speaking, fireproof.

History of Egress Laws

The early provisions in building laws specifically concerned with safety to life -- those pertaining to egress -- were relatively spare and of doubtful value. Roof scuttles, required in the laws of some cities, could not have been useful escape routes in buildings with pitched roofs. Moreover, while people undoubtedly were killed regularly in house fires, these were not the sort of fires that aroused the public. Only fires in heavy occupied buildings that caused large losses of life exercised the public and stirred lawmakers to action.

The only buildings with stairways in towers and exterior platforms and ladders -- perhaps the nation's first fire escapes -- were New England factories, as discussed in Chapter 5. As long ago as 1840, the visiting English mill-man, James Montgomery, remarked on the platforms and ladders he saw on many of the large New England mills. The stair towers were isolated from the main floors by masonry walls and fireproof doors. Separating vertical stairs from horizontal floors was a way of preventing the rapid spread of fire, and the exterior platforms and stairs, in theory, enabled firefighters to approach a blaze. Nevertheless, they also created a more protected means of egress for the workers -- more protected than an unenclosed staircase. These towers were easy to add because mills were often free-standing in their own yard. Nevertheless owners often built only one tower, perhaps to better control

the comings and goings of the work force.

Occasionally owners of other kinds of buildings paid special attention to the design of exits. The stair tower in the court that separated two parts of the Harper Brothers building in New York, discussed in Chapter 3, is an example. A drawback with the Harper stair tower, and indeed the mill stairs, was the small capacity. Stairs were not necessarily scaled for the exit of large numbers of people all at once. And one stair tower was not enough, even when augmented with exterior fire escapes.

With economics stacked against it, adequate egress would only become a general rule if required by law. Thus, history of life safety can, to some extent, be charted in the change in the sections of building laws pertaining to egress. The part of the story not told by the laws has to do with compliance and enforcement. The laws give a sense of what a community wanted; it is much more difficult to say what actually happened.

Long before American cities required anything besides roof scuttles, Parliament was requiring protected egress in London. The 1844 Building Act required that structures in the "public building" class -- buildings the public could enter -- have halls, vestibule, lobbies, and so forth, "wholly supported, constructed, formed, made and finished Fireproof." Buildings in the dwelling class also had to have fireproof stairs.² London's laws were consulted by American architects who helped draft the relatively complete building laws that first began to be adopted in U.S. cities in the 1870s. American laws at this time were much influenced by British laws.

Multi-family residences were the first type of building in the U.S. required to have emergency exits. In New York, the growing number of tenements had prompted all sorts of recommendations for amelioration, but one of the earliest to be enacted concerned exits. The proximate cause of the addition of exit provisions to New York's law was a fire in a six story tenement house on Elm Street in 1860. The fire started in a bakery in the basement of the building and spread up the stairway. The building was two stories higher than its neighbors and the longest fire ladder could not reach above the fourth floor. The occupants were

² C. C. Knowles and P. H. Pitt, The History of Building Regulation in London 1189-1972 (London: Architectural Press, 1972), p. 63.

trapped; some jumped from the windows. The press initially reported that 30 people were killed.³

The fire occurred while the New York state legislature was already investigating the safety and sanitary conditions in tenements. In 1856, a legislative committee had recommended a number of rules for tenement houses, including one to regulate halls and stairways "to insure easy egress in case of fire," but no action was taken. After the Elm Street fire, the New York Times chided New Yorkers for worrying about the welfare of slaves in the South while ignoring the suffering of residents in their own city, and urged that egress and height controls for tenements, at least, be enacted.⁴ New York City's first fairly complete building code was enacted in this year.

This code was amended in 1862 and again in 1866. The amendments of 1866 specified that all dwellings occupied by six or more families above the first story "shall have placed thereon a practical fire-proof fire-escape, that shall be approved by the department."⁵ In 1871, the applicability of egress requirements expanded. The new codes required existing as well as new buildings, and factories and office buildings in which "operatives are employed in any of the stories above the first story," in addition to multi-family dwellings, hotels, and lodging houses, to have fire-escapes, alarms, doors, and ventilators "as shall be directed and approved by the said superintendent of buildings." Scuttles continued to be required on all buildings.⁶

From their inception, American egress requirements tended to differ from British requirements in that exterior exits were an accepted form of egress. In England, a "fire escape" was a ladder on a truck brought to fires; London's laws did not contemplate the fixed platforms and ladders on the sides of buildings that Americans called fire escapes. American laws were retrospective, however, requiring egress on existing buildings, and this was most

³ New York Times, Feb. 3, 1860, p. 1.

⁴ New York Times, Feb. 4, 1860, p. 4.

⁵ Joseph McGoldrick, et. al., Building Regulation in New York City, A Study in Administrative Law and Procedure (New York: The Commonwealth Fund, 1944), p. 63.

⁶ William J. Fryer, Architectural Iron Work (New York: John Wiley & Sons, 1876), p. 166.

readily accomplished with exterior fire escapes. Fire escapes were intended for use in emergencies, when the usual exits became overwhelmed with occupants or inaccessible. The alternative to exterior escapes would have been for owners to add stairways inside their buildings, something that may have been impossible in already crowded tenement houses, for example. Thus was born a feature of urban buildings that came to characterize American cities.

Other cities began to require fire escapes about this time, and the growing market for these devices stimulated invention. A count of patents indexed by subject for the period through 1873 under the heading "fire-escape" shows that only nine were patented before 1860; and between 1860 and 1873, 108 were patented.

Even at this early date, fire escapes were not without American critics. An article about fire escapes in Architectural Review in 1869 noted that iron ladders were too difficult for people to negotiate and iron balconies, such as were accepted by New York's building chief, would, with fire lapping up the wall, become gridirons for humans. The author recommended instead the English system of walled in, fireproof stairways.⁷

Boston's building laws were among the strictest with respect to egress, and it is worth following the development of egress provisions in the laws of this city to see the most that was possible in America at this time. Boston's 1871 law required roof scuttles and permanent step ladders on new buildings; it also contained egress requirements for two kinds of buildings, tenement houses, and theaters. Every tenement, existing or future, was required to have a "proper fire-escape, or means of escape in case of fire," and the plans for buildings for "public assemblies" had to be submitted to the inspector and approved with respect to the sturdiness and the sufficiency of "the means of ingress and egress."⁸ However, in neither case did the law specify what constituted proper or sufficient egress. This was left to the discretion of the inspector. The law also contained rules for "places of amusement:" it forbade seats in passage ways and required that when such buildings were occupied, all doors were to be kept open unless the doors opened outward or could swing both ways, in which

⁷ "Fire-Escapes," ARABJ (Dec., 1869), pp. 310-311.

⁸ Acts of 1871, chapter 280, sections 19, 30, and 37.

case they could be closed.⁹

This law contained no requirements with respect to work places, a lack that was filled in the amendments to the law passed after the 1872 conflagration. Now, new buildings in which more than 25 people lived, gathered, or worked above the first floor, had to have noncombustible staircases enclosed behind noncombustible walls, of a width approved by the inspector, with outward opening doors. Further, any buildings where "operatives" worked above the second story had to have fire-escapes. Importantly, these requirements applied to existing buildings as well as new ones.¹⁰ Still, the law continued the policy of having the inspector of buildings determine whether the egress facilities -- such as the number of staircases and fire-escapes -- were adequate.

Vague as they were, these provisions probably made Boston the only city in Massachusetts with fire safety rules for factories, even though Boston was by no means an industrial center. Fire protection rules soon were extended to other cities in the state, under Chapter 214 of the Acts of 1877. The impulse behind its passage was a fire: the burning of Granite Mill No. 1 in Fall River on September 20, 1874. This fire was tragically reminiscent of the Triangle Shirtwaist fire some four decades later and though it is less well known, it was an as much a watershed event as the later fire. It ushered in the era of government responsibility for work place safety in the U.S.

The fire started on the fourth floor of a large woolen mill at the beginning of the working day. The building was equipped with standpipes, a roof tank, pump, horizontal pipes and hoses -- the standard equipment of the best mills -- but the water on the fourth floor failed to work when it was actually needed. While the workers tried unsuccessfully to put it out, it spread from the spinning machine where it began to the vicinity of the stair tower. Perhaps 90 operatives, mainly women and children, were at work on the floor above and in the attic. The mill had one stair tower and also fire escapes at the gable ends of the building. Fatefully, the only means of exit from the attic, other than the stairs, were skylights that opened onto a steep roof. By the time the workers in the attic received an alarm, the stair

⁹ Acts of 1871, chapter 280, section 60.

¹⁰ Acts of 1872, chapter 371, sections 13 and 14.

tower was filled with smoke. The workers were trapped. They crowded at the windows pleading to be rescued, and although the fire department was on the scene, their ladders could only reach half way up the mill walls. Many women jumped, falling 60 feet. Others were overcome and died in the building. About 23 people were killed and scores more were injured.¹¹ This disaster occurred before the eyes of the families and neighbors of the victims. The public outcry and recriminations were great.

Despite the many deaths, the coroner's jury did not find the mill owners negligent and also found no evidence that stairway doors were locked, as at least one worker charged they were. The jury did conclude that the means of escape from the attic and also the mill's alarms were inadequate, and urged mill owners to do more to protect the lives of their employees.¹²

One person who felt that exhortations were not an adequate response to this fire was Carroll D. Wright, the recently appointed chief of the state's young and floundering Bureau of the Statistics of Labor. In his annual report of 1875, Wright outlined a proposed "Factory Act," arguing,

A repetition of this (Granite Mill) disaster should be made practically impossible. No love of gain should be allowed to put human life at risk. The number of manufacturers who knowingly endanger the lives of their operatives is probably very small in this state; but there are undoubtedly some, and these should be restrained by law.¹³

Even the willing manufacturers, he believed, needed a law for guidance. The items in Wright's proposed legislation, which addressed other issues of worker protection besides fire safety, were meager and hardly burdensome, still opposition to the bill delayed its passage until 1877. Even so, this was the first, and for some years the only, worker protection law in the U.S. The law and also the Massachusetts Bureau of the Statistics of Labor became

¹¹ New York Times Sept. 20, 1874, p. 1; Sept. 21, p. 1; Sept. 29, p. 1.

¹² New York Times, Oct. 4, 1874, p. 5.

¹³ Sixth Annual Report of the Bureau of Statistics of Labor, Public Document 31, Massachusetts, March, 1875, p. 145.

models for those in other states.¹⁴

The language of the Act differed little from that of Wright's proposed legislation except that, with respect to egress, it actually applied to buildings besides factories. Wright may have looked to England for ideas respecting "factory" legislation, but the Massachusetts legislature looked to its own building laws, notably the building law for Boston, for fire safety precedents. Like Boston's law, Massachusetts' legislation applied to "public buildings," a category that included churches, schools, hotels, halls, theaters, and other buildings where the public assembled as well as factories. These buildings were required to have means of egress and outward swinging doors as directed by the inspectors. With respect to factories, in the statewide law, "manufacturing establishments" three stories high or more, in which 40 or more people were employed were required to have "a sufficient number of tower stairways" or else proper outside fire escapes. Boston's law put no threshold on the size of the work force.

Both laws left much discretion to the inspectors. But while Boston's inspectors were required to be "able and experienced mechanics," the inspectors outside of Boston were to be state detectives.¹⁵ Needless to say, these men could not have been well prepared to judge the adequacy of construction and egress. No standards -- dimension of exits relative to number of potential users, number of exits, characteristics of exterior fire escapes -- had even been established to give them guidance.

Besides its good intentions, the statewide law did contain a significant legal advance, and this was to establish an employer's responsibility for protecting his workers: "Any person or corporation violating any of the provisions of this act ... shall also be liable for all damages suffered by any employee by reason of such violation." And the law said explicitly that this provision did not limit a person's right to sue an employer for injuries suffered.¹⁶ After the Granite Mill fire, the coroner's jury could not fix liability because in the law at that

¹⁴ William Willoughby, "Inspection of Factories and Workshops," in Herbert B. Adams, editor, Monographs on American Social Economics, Dept of Social Economy for the U.S. Commission to the Paris Exposition of 1900.

¹⁵ Boston, Acts of 1871, chapter 280; State, Acts of 1876, chapter 216.

¹⁶ Acts of 1877, chapter 214.

time, the owners simply had none. Now they did.

The law was amended in 1880, and the threshold for when egress provisions applied was lowered. It also prohibited the employment of women and children above the second floor in buildings where there was only one means of egress. Legislators still were reluctant to require two means of egress generally.

Boston's revised building law of 1885 contained the same rules pertaining to operatives, except that Boston's law continued to apply to all building in which operatives were employed, and the egress requirements for variety of buildings were made stricter.¹⁷ Every building, existing and future, in which two families lived or people worked above the second floor, or schools over two stories high and occupied by at least 40 persons, had to have "proper facilities for escape ... in case of fire." New or renovated public buildings had to have one facade on an open way that measured at least fifteen feet across as well as "doors, halls, corridors, lobbies, stairways, passages and aisles, wide, direct, and so constructed and arranged so as to afford easy egress for the occupants under all circumstances." The law contained requirements for new theaters, about which more will be said shortly, and it also had a section specifically devoted to tenements. New tenements for five or more families had to have a fireproof stairway, enclosed in brick walls, covered with a ventilating skylight, and constructed fire resisting. Although the law continued to leave many matters, such as what constituted "easy egress," up to the inspectors, it also contained some concrete guidelines for sizing doors and stairways. For example, in new public buildings, doors had to be as wide as the corridors that led to them and had to open outward; and stairways and corridors had to be five feet wide for sections seating 300 people or less, and an additional 20 inches wide for every 100 more persons the section may contain.

Following yet another tragedy, life safety laws similar to those of Boston were enacted for the rest of the state. This time the fire was in the small city of Springfield, Massachusetts. There on the afternoon of March 7, 1888, many of the local citizens watched as several occupants of the fifth floor of a burning office building fell to their death, or were overcome and killed before their eyes, while the city's fire department tried ineffectually to

¹⁷ Acts of 1885, chapter 374.

raise a ladder.¹⁸ As usual, the fire department's was unable to fight a fire at the height of the fifth floor from the ground. The state legislature, with greater dispatch than in the 1870s, decreed that henceforth every municipal fire department would have: a gun or like device to shoot a rope up to any window; a "chute" made of canvas, also able to extend from any window to the ground; and a "jumping-net" capable of breaking the fall of any person jumping from any building.¹⁹ These requirements would be comical if the situation they were meant to address was not so serious. The Boston Journal, in an article reprinted in AABN, duly noted the drawbacks of these devices and asked that whatever future measure was adopted with respect to life safety, "let it by all means be something which is as far as possible real and trustworthy."²⁰

Soon a real egress law was adopted with egress requirements similar to those in Boston, for both existing and future buildings, which applied to all communities in the state. A novel provision of this 1888 egress Act was that inspectors, on approving a building's egress facilities, were to determine "the number of persons for whom the ways of egress or means of escape from fire are deemed to be sufficient," and to issue to the owner or lessee a certificate to this effect. The certificate expired after five years and in the meantime, if the use of the building changed, the certificate terminated and the building had to be reinspected.²¹ The certificate had to be posted. These provision both gave the occupants a chance to police the building and the community a means to control the use and occupancy of a building.

Boston's new building law of 1892 contained a similar consumer protection provision: owners or lessees could obtain a certificate "to the effect that his building is provided with safe means of egress," and tenants or employees in the building could request that the building be inspected if the owner did not have one. How effective owners and employees

¹⁸ Springfield Union, March 8, 1888, p. 1. The fire was in the building occupied the by Union, which had offices on the fifth floor. The dead were Union employees.

¹⁹ Acts of 1888, chapter 310.

²⁰ AABN vol. 24 (Sept. 22, 1888), p. 140.

²¹ Acts of 1888, chapter 426.

were in policing safety, of course, is a question. But this law did advance the cause of life safety by required "at least two independent ways of egress" for existing as well as new buildings. The rule applied to schools, churches, theaters, public buildings, halls, places of assembly or resort, multi-family residences, factories where ten or more people were employed, each accessible from each apartment.²² These egress requirements amended the next year to make clear that both means had to be flights of stairs, although the second means could "project over a public way," so presumably could be a fire escape.²³ But it could not be, say, an iron ladder attached to the wall. The notion of establishing standards for exit facilities, of scaling them to occupancy, and of licensing occupancy, was dawning.

Theater Fires and Egress Rules

The provisions with respect to theaters in Boston's 1885 law were comprehensive and for good reason: theater fires were among the most deadly building fires in the nineteenth century. It was a fire in a theater in Richmond, Virginia in 1811, in which seventy people died, that helped turn Robert Mills into a prophet of fireproof construction. One of Mills' important early commissions was the Monumental Church in Richmond, built in memory of those who perished in the fire. This church was not one of Mills' fireproof buildings, however, and churches in the nineteenth century, like theaters, were rarely built fireproof.

Until about the 1870s, theaters were simple buildings. Some were designed by architects, who may have given some attention to fire protection, but most were not. Cost, of course, was the reason as little space as possible was given to passageways. But with stage light furnished by candles or gas, stages filled with painted fabric and wooden frames stage for carrying the scenery, theaters were great fire hazards. One nervous theater-goer in 1868, for example, wrote to the New York Times about a show that featured a fire in a steamboat. The writer suggested the fire marshal investigate whether safety precautions had been taken and the audience and theater company could escape in a fire.²⁴ Theater fires were common but, as in textile mills, most were extinguished before they spread. The ones that did end up

²² Chapter 419 of the Acts of 1892.

²³ Chapter 293 of the Acts of 1893.

²⁴ Letter, New York Times, June 20, 1868, p. 2.

killing large numbers of people most frequently started when stage lights ignited scenery during a show.²⁵

Like operatives in factories, theater audiences could not trust their safety to the building owners. Owners had no liability for the death and injury of people in the theaters from fires that started accidentally. They were disinclined to devote space to stairways and corridors, to limit the number of seats in order to improve egress, or to buy valuable street frontage to increase the number of doors at the main entrance. If they could have been rewarded for taking such measures -- if theater-goers would pay more to attend a show in a safe theater or refuse to attend shows in dangerous theaters -- the owners may have done so. As AABN noted after a deadly theater fire in 1876, the public have would wait a long time before market forces yielded results. People in the mood to attend a popular show were unlikely to worry about the safety of the building: "The burden of care which the theatre-goers will not bear (themselves), the municipalities must take up. ... (The audience's) protection can be assured only by enforcing very stringent rules concerning the arrangement, construction, and care of theatres."²⁶

AABN was writing with reference to what was probably the worst American theater disaster to date, the Brooklyn theatre fire in December, 1876, in which nearly 300 people were killed. The fire, which started on the stage, precipitated a stampede for the exits. The greatest loss of life was among the people in the gallery seats, who had only one narrow, winding stairway by which to escape. This exit became blocked and the stairs collapsed. Yet the theater was a relatively new one, having been constructed in 1871, and its exit facilities were in no way worse than those of other theaters.²⁷

Immediately after this fire, a committee of architects from the New York chapter of the A.I.A., including members of the committee that recommended candidates for building department jobs, drafted legislation covering construction and management of theaters. Their

²⁵ William Gerhard, "Theatre Fire Statistics," AABN vol. 46 (Dec. 15, 1894), pp. 115-116.

²⁶ AABN vol. 1 (Dec. 16, 1876), p. 402.

²⁷ AABN vol 1. (Dec. 16, 1893), pp. 406-408. The building was designed by Thomas A. Jackson.

proposed law went to the state legislature in 1877, but was never enacted as such.²⁸ Rather, it eventually was incorporated in New York's revised building code of 1885 and also was the model for theater provision in Boston's new code of the same year. The rules in both cities' codes are quite extensive and similar, but there are some differences. New York's theater rules followed the A.I.A. draft law closely and were contained in one lengthy section of the building law.²⁹ In Boston, some of the exit rules that in New York applied only to theaters also applied to "public buildings."³⁰ Both cities required that theaters have access to an open way, but New York's law, in addition, required that two sides as well as the front of the theater open to passage ways, for the length of the building that included the seating section. American theaters, with a few exceptions, such as the Academy of Music in Philadelphia, commonly covered the entire lot, although free-standing theaters were standard in some European cities. The now familiar pattern of three free sides for American theaters post-dated New York's law. Otherwise, the laws vary in some details: dimensions for corridors differ slightly, with New York's being less generous than Boston's, and New York's law contemplated outside fire escapes for the upper levels of theaters, while Boston's law required two independent exits for each division, which could be either interior or exterior.

Another notable feature of the codes of these two cities is that now theaters, like tall buildings, had to be fireproof. Boston's law required that theaters "be of fire resisting construction throughout, so far as the nature of its uses will permit." While New York's law contained no such general statement, it specified that exterior walls; interior walls enclosing stairs, separating the auditorium from the lobby and stage; partitions; the proscenium arch; and the main floor, floor over the lobby and the corridors, be fireproof, which left little in the building that could not be fireproof. Theaters were the only kind of building that had to be both fireproof and have ample facilities for egress.

²⁸ AABN vol. 1 (Dec. 30, 1876), p. 423; AABN vol. 6 (Sept. 6, 1879), pp. 75-77.

²⁹ William Fryer, Law Relating to Buildings, in the City of New York (New York: The Record and Guide, 1885), pp. 40-50, section 500. Fryer, in a footnote, implies that the architect Frank Kimball, who was a prominent theater designer, wrote the law. But Kimball was not on the committee that drafted the original bill, and the provisions as adopted are virtually the same as the draft. Perhaps Kimball was responsible for the such changes as there were.

³⁰ Act of 1885, chapter 374, sections 126 to 139.

The architects had proposed, and New York's law included, the requirement that every theater post fire safety regulations for the building and a floor plan showing exits. This idea of posting floor plans caught on. A theater ordinance under consideration in Chicago at the end of the decade would have required that plan of theaters showing stairs and exits be printed in every program.³¹ This idea that was adopted in other cities. New York's 1885 law contained one important provision not in the draft law, which was that every exit be marked "EXIT." This idea may not be on the order of Edison's light bulb, but it was new in the U.S. Posting of floor plans and marking exits eventually became standard life safety features for all public buildings.

Hard Lessons

The rules for fire protection and egress in theaters contained in model codes, such as Boston and New York's 1885 codes, were very complete, but whether even they would accomplish their desired objects with respect to life safety was uncertain. For other kinds of buildings, even factories, the requirements were meager, and whether the vague standard of goodness and sufficiency was satisfied largely was left to an inspector to decide. Were the facilities built in compliance with the law adequate? What exactly were they supposed to accomplish? The fact was, compared to the advances in understanding of how to build fireproof, standards concerning life safety were extremely rudimentary. Few people had devoted themselves to studying this particular matter, and the nature of the problem and goals for egress were just beginning to be conceptualized. Providing means that were adequate to achieving ends, then, awaited the formulation of what those ends were, and acceptance of these principles by lawmakers and the public.

Thus, until something better came along, much reliance was placed on exterior fire escapes for emergency egress. They were perhaps the only practical way to augment egress facilities in existing buildings. But exterior fire escapes also were allowed, or even required, in new construction. Moreover, the laws gave few guidelines concerning acceptable designs for fire escapes.

³¹ Chicago correspondent, AABN vol. 23 (March 24, 1888), p. 136. Boston's 1892 building act required that "plans showing the exits and stairways shall be printed on every programme or playbill." (Acts of 1892, chapter 419, section 96.)

Deadly building fires showed that the fire escapes and roof exits were often ineffective in saving life. In the Granite Mill fire, for example, the women and children trapped on the upper floors made little use of the fire escapes. Some people afterwards intimated that these women were cowardly and irrational and might have survived had they used the escape facilities; but the fact was, there were many good reasons for their reluctance. First, the workers were not accustomed to using them. Surely no one had practiced climbing down the outside fire escapes or going up on the roof when they were not in a state of terror. Second, the fire escapes were scary. Even Boston's law required little of fire escapes except that they be unobstructed, have railings, and extend to the ground: nothing as far as loads and features that would make them easy to descend. The theater section of New York's 1885 law contained some specifications for fire escapes in theaters, but nothing definite for fire escapes on other buildings.³² Charles Woodbury, inspector with the New England mill fire insurance companies, had seen many fire escapes and concluded, "Most of the fire escapes are put up so as to conform to the letter of the law; and in such manner that no one but a sailor or an acrobat would be likely to trust himself to them."³³ Woodbury suggested stair towers, with straight-run (not spiral) stairs, were the only completely reliable exit facilities.

Besides the problem of design of fire escapes was maintenance. Because they were infrequently or never used, they fell into disrepair. New York's 1885 law required a plaque be installed on balcony fire escapes with the message, "Notice! Any person placing any incumbrance on this balcony is liable to a penalty of ten dollars and imprisonment for ten days." This rule against encumbrances, along with the requirements that fire escapes be kept "in good repair and well painted," probably were not strictly enforced.³⁴ The purpose of fire escapes was sometimes defeated in unbelievable ways. Edward Atkinson publicly complained that the gates on fire escapes on Boston school buildings were locked with padlocks.³⁵

³² William Fryer, Law Relating to Buildings in the City of New York (1885), p. 39.

³³ C. J. H. Woodbury, "The Evolution of the Modern Mill," Cornell University Non-Resident Lectures in Mechanical Engineering, Scientific American Supplement no. 647, p. 10330.

³⁴ William J. Fryer, Jr., Laws Relating to Buildings in the City of New York, pp. 39-40.

³⁵ Harold Williamson, Edward Atkinson, p. 125.

Both the lawmakers and building owners needed standards for fire escapes, but even more, they needed standards for exits in new construction and rehabilitation, and for the design of a building, such that the reliance on outside fire escapes was reduced. One type of "fire escape" that was praised by fire protection experts was a kind required by Philadelphia's turn-of-the-century building code, known as the Philadelphia fire tower.³⁶ This fire escape was actually a stair tower enclosed in noncombustible walls. It was accessed either by a balcony or by a porch. In either case, a person had to leave the building to enter the stair tower and thus smoke would flow out the door connecting to the floor of the building and up into the air, not into the stair tower. This arrangement solved the problem of how to keep smoke and flames out of a stair tower connected to the floor of a building, when the doors to the tower were held open by workers trying to escape.³⁷ It was required in stores in which any floor above the second had a clear area of 4,000 square feet, factories of three or more stories with 3,000 square feet per floor. The tower does not seem to have become common outside of Philadelphia, perhaps because it was essentially an extra staircase, which could be incorporated in new construction in other forms.

Another means of safe egress accomplished in the design of a building was called "fire wall escapes." A building was divided by a fire wall; openings in the wall were protected with automatic doors. The walls were intended to contain a fire in the section of the building where it started, so people could escape to the other side of the wall and then down the stairway serving that side of the building to safety. This solution was recommended by fire authorities at the turn of the century, but the wall was an inconvenience and most owners preferred other ways of solving the egress problem.

Not only did exits have to be sufficient in number and capacity, but people had to be accustomed to using them. The Brooklyn theater fire of 1876 illustrated this point: the crowds left by familiar routes, even though other means of exit were available. One lesson drawn from this event was that a building had to be planned so that people would not all

³⁶ Arthur McFarlane, "Fire and the Skyscraper," McClure's Magazine vol. 37 (Sept., 1911), p. 481.

³⁷ Discussed by John R. Freeman, On the Safeguarding of Life in Theatres; Being a Study From the Standpoint of an Engineer, address to the annual meeting of A.S.M.E., Dec. 4, 1905, reprinted privately from the Transactions of the Society, p. pp. 90-92. Also described in

converge on only one exit. To do this in a theater, the audience had to be segmented, with exits serving each segment, and occupants of the various segments forced to leave by the exit serving their particular seating section regardless of how they entered, so that they would become accustomed to that route. Moreover, the various streams had to be dispersed, and not converge on the lobby.³⁸ These principles were incorporated in the more advanced building laws with respect to theaters.

They also suggested that people had to learn the location of emergency exits if these differed from the ones commonly used. How to do this in buildings other than theaters was more complicated. It was probably in schools that the idea of establishing a plan for exiting a building and training occupants to follow it was first introduced. In the same month as the Brooklyn Theatre fire in 1876, a fire occurred in a school in Minneapolis, but in this case tragedy was averted. The students exited in an orderly way and thereby survived. In reporting on this event, AABN recommended that all school committees follow the example of Chicago, where students were "subjected to a special drill in order to accustom them to disperse rapidly and safely."³⁹ Schools around the country began to adopt the idea, and thus children learned to escape from school buildings.

It was many years, apparently, before anyone thought of transferring the idea of fire drills to work places and to adults. H. F. J. Porter, a mechanical engineer and manager at a factory in Pittsburgh, discovered that escape from his factory would be impossible in the event of a fire or panic. He tried to find whether any factories had drills such as those used in schools, but could not find one. So he added outside ladders and trained his workers to use them and other exits to escape from the building. With practice, the building could be emptied in three minutes. This occurred in 1904 and was, as far as Porter knew, the first work place fire drill. Porter went on to become a manufacturing consultant and "installed," as he termed it, fire drills at the factories where he worked. Of course, he also found that

³⁸ "The Security of Theatres," AABN vol. 1 (Dec. 16, 1876), pp. 402-404.

³⁹ AABN vol. 1 (Dec. 23, 1876), p. 409.

additional egress facilities often were required in order to have a workable exit plan.⁴⁰ In the course of his work, he developed estimates of necessary dimensions for exits, locations for exits, and the maximum time allowable for clearing a building. This last item was a vital factor: the capacity of egress facilities needed to empty a building in three minutes or in five were not the same. But theater fires had shown that at five minutes, everyone who could be suffocated by smoke was dead.

This was the beginning of objective studies for developing egress standards. A fire drill was not merely a matter of practicing since, as Porter had found, existing facilities might not be adequate. In many cases, factories had grown in size -- added wings or floors -- but exits had not increased. Once ample exits were installed, a plan had to be devised and workers drilled. The chapter on fire drills in fire expert Peter McKeon's textbook is illuminating of the problems of conducting fire drills in the factories of the day, where many workers were recent immigrants. Workers must be informed of the purpose of the drill, he wrote; notices should be distributed so workers could take them home "and those who do not understand them fully can have them explained by other persons or by children, who are familiar with the fire drill as carried out in the public schools." McKeon concluded, panic and confusion, as much as lack of exits, had caused much loss of life: "it is to avoid these things that the Fire Drill is used."⁴¹ Fire drills, like other safety measures, did not become widespread in work places until they were mandated by law.

Egress and Fireproof Construction

As previously suggested, emergency egress was considered a problem in buildings used for certain purposes. It was not considered a special problem for tall buildings, as such, for two reasons: tall buildings were usually office buildings, which presented few fire hazards, and tall buildings were fireproof. Two terrible events in the early twentieth century proved that fireproof construction did not necessarily protect the occupants of a building when there was much inside the building to burn, and that tall buildings, even if fireproof, did

⁴⁰ H. F. J. Porter, "The Fire Hazard," appendix II in Preliminary Report of the Factory Investigating Commission, State of New York, Senate Report No. 30, March 1, 1912.

⁴¹ Peter J. McKeon, Fire Prevention (New York: The Chief Publishing Co., 1912), pp. 149-151.

indeed present special egress problems.

The Iroquois Theatre Fire

Chicago followed the lead of New York and Boston and passed a law requiring that theaters be of fireproof construction. The year the law was proposed, 1888, a fire occurred at a theater that claimed to be "the only absolutely fireproof theater in the city," the Chicago Opera-house. This theater occupied the lower floors of a ten story office building, completed 1885, which was fireproof.⁴² However, the theater itself was not strictly fireproof, since an "attic" above the stage and the gallery were built of wood. It was extensively damaged, more by water than flames, but as the audience had already left the theater, no person was hurt. After the fire, a correspondent to AABN noted, the theater advertised itself as "fireproof" instead of "absolutely fireproof."⁴³ Presumably future theaters, if built in compliance with the law, would be genuinely fireproof. But this correspondent also remarked about the incident, "as is usual in theater fires, in an incredibly short time the building was filled with smoke." There was much to burn in every theater, even if the structure was excluded as a potential source of fuel. Fireproof construction in itself could not prevent smoke.

This incident also reveals some of the potential problems of enforcing the codes. The Opera House Block probably was commenced before the city's fireproof construction law took effect, but at any rate, changes made to the gallery while it was under construction, in order to improve the sight lines. These changes could only have been caught by an inspector if he happened to be on site while the changes were being made. Over-worked inspectors could not always be present to catch such changes. Or the inspector may have looked the other way. The building department in Chicago did not have a reputation for integrity. As Henry Ericsson, a builder who in 1911 was appointed the Chicago's building commissioner,

When McAndrews had been building commissioner (1897-1901), his office was actually in the mayor's office, and as a builder I can testify that the office was not expected to exert any particular influence or control over building as such. This has been the history of the office through successive administrations.⁴⁴

⁴² Peter Wight believed it was, IA vol. 5 extra no. (April, 1885), p. 53.

⁴³ AABN vol. 25 (February 16, 1889), p. 79.

⁴⁴ Henry Ericsson, Sixty Years a Builder, p. 298.

An example of this history of negligence, if not corruption, was that while the city's theater law required automatic sprinklers over stages, not one theater had them.⁴⁵

Among the new fireproof theaters constructed in Chicago was the Iroquois on Randolph Street, which opened in 1903. At a Christmas-time matinee in that year, with 1,830 people in the attendance, a light ignited drapery on the stage. The fireproof stage curtain, required by law, became stuck as the stagehands tried to lower it; the smoke vents over the stage were blocked. Air rushed in when the fleeing actors opened a door in the stage area and smoke poured into the auditorium. The fire department was on the scene quickly, about five minutes after receiving an alarm. But by then it was too late for hundreds of theatre-goers. Five hundred and eighty people died, most of whom were killed by the smoke. The great majority of the dead had been in the gallery seats: 70 percent of the people in the gallery were killed.

A Chicago businessman who lost two nieces in the fire, asked the Factory Mutual official and engineer, John Ripley Freeman, to come to Chicago to investigate and recommend corrective actions. Freeman's findings were contained in a paper to the A.S.M.E., which was also published separately, On the Safeguarding of Life In Theaters. His principal recommendations were as follows: the design of the smoke vents over the stage should be improved so that they actually open when needed; the stage should be equipped with automatic sprinklers; and the gallery must be supplied with adequate exits. He also concluded that fireproof paint, such as was required for scenery, was of little use; asbestos curtains were too insubstantial and their purpose could be better accomplished by functioning stage vents; and that dry powder fire extinguishers and "hand grenades" (glass bottles containing some liquid) were useless. (Illustration 7-1.) The recommendation he considered most consequential for saving life was for better vents over the stage. If the vent in the Iroquois had opened, Freeman believed, the smoke would probably have been drawn up and out of the building, and not suffocated the audience. He recommended that all future stage vents be closed by a device that would cause them to open automatically if the temperature of the air rose. Vents ordinarily were closed with fiber rope, which was supposed to burn in a

⁴⁵ John R. Freeman, On the Safeguarding of Life in Theaters, p. 10.

Illustration 7-1. Hand grenades and fire buckets, 19th century fire extinguishers.

FLAT BOTTOM.
 10 qts. \$4.50 per dozen.
 12 qts. 5.25 per dozen.
 14 qts. 6.00 per dozen.



**HEAVY GALVANIZED
 Fire Buckets.**

Write for Discount.

**FRANK E. FITTS
 MFG. & SUPPLY CO.,**

88 Purchase Street,
 Cor. Oliver,
 BOSTON.

ROUND BOTTOM, 10 qts., \$6.75 per doz.
 " 12 qts., 7.25 per doz.
 " 14 qts., 7.50 per doz.

This bucket is made to set in a rack, or to be hung on a hook, to be used in case of fire only. It will not stand alone, and cannot be used by workmen for other purposes.



Protect Yourself Against FIRE.

Hand Grenades

The Only Sure Protection.

Ever Present and Always Faithful.

MORE THAN 1000 FIRES PUT OUT LAST YEAR.

FRANK E. FITTS MFG. & SUPPLY CO.

88 Purchase St., Cor. Oliver, BOSTON.

fire and release the doors of the vent; but even if the doors were not frozen shut, Freeman felt the reliable and responsiveness of the cord was not as good as a fastener held by the same "fusible solder" used in automatic fire door, fire shutters, and sprinklers. These links, which were made by automatic sprinkler manufacturers, had not found their way into theaters.

All of these suggestions pertained to the equipment and management of the theater, not to its construction. In fact, the Iroquois building held up very well,

What has been called the irony of fate is found in the fact that the scene of this appalling disaster was the newest of Chicago's theaters, a building of fireproof construction that justified the name, so far as the building itself was concerned.... Little except scenery, decorations and upholstery was damaged by the fierce fire.⁴⁶

The theater, indeed, was fireproof. It was required to be by law, but as we have seen, this would not have made it so. Besides having a law-abiding owner, what may have helped make it fireproof in reality was that the owner could get a much better rate of insurance if his theater was fireproof. By this time, local insurance rating agencies were varying rates according to the construction of buildings, and building fireproof was financially advantageous for the owner. The average cost of insurance for theater buildings in Chicago at the time of the fire was 3.7 percent but only one percent on the best fireproof theaters.⁴⁷

However, the owner did not insure lives of the audience and could not realize any financial savings by protecting them. In fact, the owner's liability was only what the building law defined it to be. Ericsson recalled that the long and violent litigation over the Iroquois ended with the finding that the 581 bodies "did not result from the failure to install a sprinkler system and such other safeguards as the ordinances required."⁴⁸ And Chicago's aldermen acted quickly to bring all the theaters in the city into compliance with the building law, by amending the law so that sprinklers were no longer required.⁴⁹ Ericsson's autobiography recounts his efforts to clean up the building department during his tenure as chief, and convince owners to obey the law. But with one aspect of the law -- building

⁴⁶ J. R. Freeman, On the Safeguarding of Life In Theaters, p. 12.

⁴⁷ J. R. Freeman, On the Safeguarding of Life in Theaters, footnote p. 7.

⁴⁸ H. Ericsson, Sixty Years a Builder, p. 306.

⁴⁹ J. R. Freeman, Safeguarding of Life in Theaters, p. 10.

fireproof -- they seemed to be complying.

New Scope for Structural Fire Protection: After the Triangle Shirtwaist Fire

As the Iroquois tragedy showed, fireproof construction alone was not enough to safeguard life. The smoke from the burning contents of a building could be deadly, apart from fire itself. People could be crushed in a stampede for the exits, even at a false alarm. Escape from floors high above the ground, when a building was heavily occupied, was a problem on par with that of exiting from the gallery section in a theater.

Also, some fire experts were beginning to recommend sprinklers even for fireproof buildings. In buildings where there was much to burn -- such as warehouses, factories, and stores -- sprinklers were an important safeguard regardless of the materials of construction. In tall office buildings, even ones that presented little hazard, fires were difficult to fight at the higher levels and therefore sprinklers provided a valuable auxiliary means of protection.⁵⁰

New York's fire chief in the early years of the twentieth century, Edward Croker, was among the few fire protection authorities in New York to urge wider use of automatic sprinklers. He also believed that egress facilities in many tall buildings were inadequate for the number of occupants. As he explained his views to a grand jury investigating another deadly fire, in 1911,

There are few fire escapes in any of these office and loft buildings of the so-called modern fireproof type. ... These buildings are not fireproof, although they are called such. They are fireproof, yes, when the builders get through and before the tenants move in. But after the tenants are in they are only slow-burning buildings. They are safe so far as property damage is concerned, but not so far as human life is concerned.⁵¹

Although they were not experts on fire protection, as so were more easily dismissed as alarmist, reform organizations and unions also tried to get the government to do something about the safety of workers in tall buildings. In 1908, the New York Federation of Women's Clubs urged New York's Board of Aldermen to pass an ordinance that would have made fire

⁵⁰ Joseph Freitag, Fire Prevention and Fire Protection (New York: John Wiley & Sons, 1921), p. 866.

⁵¹ New York Times, March 26, 1911, 5:1

drills compulsory in factories, but without success.⁵² Following a deadly factory fire in Newark in 1910, the Federation brought its bill, which required weekly fire drills, to the State legislature; it was not enacted. Although wages were the main issue in the shirtwaist workers strike of 1909, strikers also complained about dangerous working conditions. The cloak and suit workers, who struck the following year, had similar concerns. A group formed to investigate their complaints found safety defects in the majority of the lofts they inspected, the principal ones being too few fire escapes and doors that opened inward, contrary to the factory law.⁵³ Yet lawmakers could not be convinced that new measures were needed.

The event that brought about Chief Croker's testimony regarding the safety of tall buildings occurred on March 25, 1911. A fire started at the close of the working day on the eighth floor of a loft near Washington Square in Greenwich Village, in the workshop of a blouse manufacturer. There was some delay in notifying the fire department and by the time the firemen arrived, fire had engulfed the top three floors. The fire department could not fight the fire from the ground and its ladders could not reach the eighth floor. The fire simply burned itself out.

This fire was in a fireproof building, called the Asch Building, and the building performed largely as intended, although the fire was not confined to the floor where it started, but had spread up the stairways and through the windows to the upper two floors. Also, the internal fire fighting system may have been inoperative, but even if it had been working, it is unclear that anyone in the building could have used it effectively to fight a fire. Still, the damage done to the structure was minor. In the newspaper the next day, a reporter marvelled that the building "shows now hardly any signs of the disaster that overtook it. The walls are as good as ever; so are the floors; nothing is the worse for the fire except the furniture...."⁵⁴ Except too, he went on to say, for the 141 workers who were killed in the fire.

This was the infamous Triangle fire, far less deadly than the Iroquois fire but more

⁵² Report of H. F. J. Porter, industrial engineer, in Preliminary Report, New York Senate No. 30, 1912, vol. 1, p. 160.

⁵³ As found by the Joint Board of Sanitary Control's Fire Protection Investigating Committee, reported in The New York Times, March 27, 1911, 1:2.

⁵⁴ The New York Times, March 26, 1911, p. 1.

horrifying, because of the way the people died. About 600 people were at work on the three floors occupied by the Triangle Waist Company that day. One of the stairway doors may have been locked. But these doors opened inward in any event and became blocked with bodies; the elevators became inoperable soon after the fire broke out. A small, exterior fire escape collapsed under the weight of fleeing workers. Crowds of New Yorkers watched while workers jumped or were pushed from the windows, falling 80 or more feet. None survived.

The building law that was in effect when plans for the Asch were approved required that the Asch, at 135 feet, be fireproof, and it was, a metal frame and tile building. Had the it been one story higher, the law would have required it to have four stairways. The Asch only had to have three stairways. But the owner applied for an exception from these minimal exit facilities, and the building department allowed an exterior fire escape to substitute for one of the three staircases required under the code. As built, only two staircases -- so narrow that the stairway doors would have blocked them had they opened outward and so were built to open inward -- served a building with ten floors of about 10,000 square feet each.

With hindsight, the building department seems at best negligent in having granted this variance. There certainly were no "practical" obstacles to complying with the law (the standard for granting an exception). Substituting an outside fire escape for a staircase was a financial boon to the owner. But had the building been used as the owner claimed it would be, as a warehouse, these egress facilities may have been sufficient.

The trouble was, there was no mechanism in New York's law, or those of most cities, for controlling occupancy in relation to the capacity of exits. The building department did not have to be notified when the use of a building changed from warehousing to manufacturing. But increasingly, with the availability of building-wide power and small electric generating engines, loft buildings were being used for manufacturing. Firms in the city's booming garment industry, in particular, were setting up in the uptown loft buildings.⁵⁵ The new high-rise lofts were attractive, compared with the old tenement shops,

⁵⁵ Nancy Green, "Sweatshop Migrations: The Garment Industry Between Home and Shop," David Ward and O. Zunz, eds., The Landscape of Modernity (New York: Russell Sage Foundation, 1992.)

for several reasons. First, with the larger floor areas, firms could expand their operations and gather all their employees under one roof. Second, more workers could be packed on the floor of a new loft than in the low-ceiling shops. New York State labor law limited "factory" occupancy to 250 cubic feet per worker, a standard that was established to assure adequate ventilation. This requirement could be met in a building like the Asch, which had 10 foot floor-to-ceiling clearances, with a mere 25 square feet of floor area per worker. Thirdly, tenants in fireproof lofts like the Asch paid lower insurance premiums. Thus, some of the lofts became high-rise factories while having exit facilities more appropriate for warehouses.

The public outcry following the Triangle fire put fire safety on New York's legislative agenda. When the fire occurred, during the 1911 session of the State legislature, Democrats were in the majority of both houses for the first time in eighteen years, and even the governor was a Democrat. Immediately after the fire, a Committee on Safety was formed, which included prominent businessmen, political figures, and reformers, for the purpose of pressing the legislature to enact better worker protection laws. Representatives of the Committee and others met with Alfred E. Smith, majority leader in the Assembly, and with Robert F. Wagner in the Senate, and proposed a joint commission to study factory conditions. A bill creating the Factory Investigating Commission passed with little opposition, with Wagner and Smith as chair and vice-chair, respectively.⁵⁶

Although fire was reason the commission was established, in fact most of the commission's research concerned occupational health and safety conditions generally, including wage rates and home work, statewide. Fire was actually a small issue for the commission, not because it was unimportant but because of all issues, ironically, it was the easiest one to solve. And the reason for this was that so much thought and study had already been applied to its solution. Had the Asch not been fireproof, some of the 450 people that escaped from the Triangle shop would have lost their lives. The missing elements were precise standards for egress, control of occupancy, and strict enforcement of the building laws.

For this reason, the proposals for legislation made by the Factory Investigating

⁵⁶ Alfred E. Smith, Up to Now - An Autobiography (New York: Viking Press, 1929), pp. 87-93.

Commission with respect to fire safety seem rather humdrum, incommensurate with the catastrophe that prompted them. The recommendations that were enacted forbade smoking in factories; required daily removal of waste; limited the number of occupants per floor and set stairway capacity standards according to allowable occupancy; and required fire drills. Even the idea of controlling occupancy, although new for New York, was already part of Boston's laws.

With respect to the fire protection of buildings, there was little more to suggest, except to ban the use of any wood in tall buildings -- in the floors, window frames, and partitions. The Commission hesitated to recommend one major fire protection item, automatic sprinklers, because of accusations of price fixing by a group of sprinkler manufacturers whose systems had been approved by the National Board of Fire Underwriters. The Commission apparently believed these allegations since it did not include sprinkler standards in the legislation it proposed in 1912, even though it was convinced of the value of sprinklers.⁵⁷ Fireproof construction had merited its name. The problem of life safety now required comparable attention.

The issue began to get attention. The National Fire Protection Association (N.F.P.A.) embraced the new focus on safety to life. This organization was the nation's principal membership organization concerned with fire prevention and protection.⁵⁸ Its early objectives and resolutions, and the standards it developed, had concerned building design, fire prevention, and equipment for fire fighting. Now safety to life was added to its list of concerns. As the N.F.P.A.'s Committee on Fireproof Construction noted in its report of 1911,

Many of the fireproof buildings of today ... present some problems in the safety of the life of their occupants which may be properly considered by this Association. The Asch building and the Iroquois Theater illustrate in a horrible way the fact that while the property loss may be quite moderate, lives by the hundreds may be lost in so-called fireproof buildings, primarily because the means for promptly extinguishing small fires may be lacking and also that means of exit are inadequate.⁵⁹

⁵⁷ Preliminary Report of the Factory Investigating Commission New York Senate No. 30, 1912, vol. 1, p. 43.

⁵⁸ Peter McKeon, Fire Prevention (New York: The Chief Publishing Co., 1912), p. 9.

⁵⁹ National Fire Protection Association, Proceedings of the 15th Annual Meeting, May, 1911, p. 61.

Two years later, this committee expanded the definition of a fireproof building when it defined a "Standard Building," one with the "greatest fire-resistance," as being,

one in which the lives of the occupants are properly safeguarded against fire and panic; so designed and equipped, that the damage resulting from exposure to fire from within or without, shall be reduced to a minimum; and capable of sustaining complete burn-out of its contents without serious injury to its structural members.⁶⁰

It also recommended that the term "fireproof construction" be dropped from the committee's name as "inappropriate," and that the committee be renamed "Committee on Fire Resistive Construction."

To begin to formulate recommendations with respect to the egress, a newly formed committee on safety to life studied current egress provisions in state and city ordinances and concluded that most were deficient. In fact, the committee found that the N.F.P.A.'s own statistics failed to include information on loss of life or injuries from fires. The year after the Triangle fire a report on "exit drills in factories, schools, department stores, and theatres," was presented at the annual meeting. In 1914, the Association adopted an egress code, "Egress from Buildings." Committees subsequently continued to study egress matters, fire escapes, exits in factories. The first edition of its "Building Exits Code" was published in 1923.⁶¹

Synopsis

The development of building laws traces the evolution of American's expectations with respect to the safety of city buildings. In the nation's early history, the main concern of the laws was preventing the spread of fire from building to building. Building laws advanced, in the sense of becoming stricter, often after disasters, and then only when the parties most directly affected by the laws agreed to changes. Many of the parties affected by the law -- for example, architects, fire insurance underwriters, and owners of valuable buildings -- also were the ones who pushed for stricter regulation.

If an owner wanted more security for his own building and its contents, he could build fireproof. Throughout the century, successive systems of fireproof construction were

⁶⁰ National Fire Protection Association, Proceedings of the 17th Annual Meeting, May, 1913, p. 133.

⁶¹ Percy Bugbee, Men Against Fire (Quincy, MA: N.F.P.A., 1971), p. 181; N.F.P.A. 101 Life Safety Code 1985 (Quincy, MA: N.F.P.A., 1985).

introduced, each one overcoming one or another of the disadvantages of the preceding systems. But fireproof buildings were considerably more expensive than buildings of ordinary construction. Consequently, only a limited group of owners built them. Nevertheless, the conflagration problem persisted, making fireproof construction attractive for certain owners.

The great fires of Chicago and Boston in the early 1870s were turning points in the history in fireproof construction. Architects, engineers, insurance underwriters, and building materials manufacturers began to devote themselves to the problem of building fireproof. Their understanding of how build fireproof improved, and a greater variety of materials for fireproof construction became available.

Beginning in the 1880s, a number of cities began to require that certain kinds of buildings which posed particular public safety hazards -- very tall buildings and theaters -- be fireproof. The number of owners affected by these requirements was fairly limited, and tall buildings were likely to be constructed with noncombustible materials in any event. In the next decade, the scope of the laws expanded so that a greater variety of kinds of buildings were required to be fireproof. Tragic fires softened resistance to stricter rules. The growing wealth of property owners in downtowns made requirements of better construction palatable, and the increasingly crowded conditions in cities made them necessary. By the turn of the century, fireproof buildings had been tested in conflagrations and had performed well: the structures remained intact and could be repaired. After the San Francisco fire of 1906, America's era of urban conflagrations came to a close.

The increasing fire resistance of buildings helped bring about this result, but ending conflagration was not all the public expected from buildings called fireproof or fire resisting. They expected to be safe in such buildings. Assuring their safety was not the same as assuring the safety of the structure, especially with buildings being larger and containing greater numbers of people. People needed to be protected from burning contents of building, and, foremost, they needed to be able to exit quickly in an emergency. Deadly fires, again, taught the lesson that fireproof construction of itself was not enough. By the early twentieth century, provision of egress and automatic fire suppression appliances also became part of the building laws.

All of these rules have raised the cost of construction. On the other hand, the rules

have led to greater safety, as we should expect, but also technological innovation, which we might not expect. Building codes always relied on available technology to accomplish the ends sought. In this respect, the laws were conservative. However, in the case of fireproof construction, the laws helped create a market for what were novel construction materials. In New York, where materials manufacturers were eager to introduce new products, the laws were frequently revised to allow new systems, and the law also provided a mechanism for allowing new materials not recognized by the law. The out-pouring of new products was tremendous. These products are the ancestors of the materials used today to construct commercial buildings.

Today, buildings in America's downtowns, buildings the public can enter, are, to use the now obsolete term, fireproof. And buildings constructed in compliance with proper exit codes, with automatic sprinklers, are in the popular understanding of the word "fireproof," in that reasonable safeguards have also been provided for the human occupants. The laws have made these buildings comparatively safe. Today,

Fire deaths, and to a lesser degree fire injuries, are overwhelmingly concentrated in homes and garages. ... The U.S. fire death problem therefore is not a matter of large death tolls in large buildings, although these incidents dominate the news. Most people who die in fire die in ones and twos in the very places where they feel safest--their own homes and vehicles.⁶²

⁶² John Hall, Jr. and Arthur Cote, "America's Fire Problem and Fire Protection," in Arthur Cote, ed., Fire Protection Handbook (Quincy, Mass.: National Fire Protection Association, 1991) 17th edition, p. 1-7.

Glossary

Arch A curved structure that crosses a horizontal opening and, when it supports a load, does so mainly by compression. The underside of an arch may be either curved or flat.

Beam A horizontal structure that crosses a opening, which a load mainly by bending. A large beam is usually called a girder. A smaller beam, supported by girder, which supports a floor is called a joist.

Beton French word for concrete.

Centering Temporary wooded framework made for constructing masonry arches or concrete arches or slabs.

Concrete In the nineteenth century, a mixtures of some bonding material, e.g., lime or cement; water; and an aggregate, such as sand, stones, coal ashes. Also called "artificial stone."

Deafening A layer of material, usually concrete or mortar, placed between layers of a floor -- the sub-floor and the walking surface -- in order to muffle sound. If made sufficiently thick, this layer also serves as a fire barrier.

End construction Hollow tile floor arches in which the cavity of the block is perpendicular with the beam.

Fire-clay A kind of clay that has great resistance to heat. It was used to make bricks to line furnaces.

Fire prevention Eliminating and reducing the causes of fire. Banning smoking in a factory is a fire prevention measure.

Fire protection As applied to buildings, designing and equipping a building so that a fire on the inside can be controlled, damage can be readily repaired, and the building will be safe against fires on the outside. Building a firewall to divide the floor area of a large building is fire protection measures.

Fireproof building A building in which no combustible materials (i.e., wood) enter into its structure, designed so as to limit the spread of fire internally, and be safe against fires originating outside the building.

Flange Projecting part of a beam or column. On an I beam, for example, the horizontal top and bottom parts are called flanges. Flanges may be formed on cast iron columns, for example, along the sides for holding fireproofing tile or at the top, to connect the columns vertically.

Girder A large horizontal structural member that goes across an opening and supports a floor and roof.

Grillage In foundations, a framework of logs, rails, or beams at in layers, each layer at right angles to the lower one, used to support walls and prevent unequal settling.

Groin Usually defined as the curved edge at the juncture of two intersecting vaults.

Gunpowder magazine A building for storing gunpowder and ammunition.

Hydraulic cement A kind of cement that hardens under water and forms a much stronger mass and stronger bond than common mortars. It can be natural or "artificial" (Portland cement).

Joist A horizontal support that is part of the floor framing.

Panelled A style of ceiling in which the girders are below the floor framing and creates an effect is like that of a panelled door.

Pier A vertical support, made of masonry; it can be free-standing or part of a wall. Wall material concentrated between openings, carrying the floor loads, are called piers.

Portland cement Hydraulic cement that is made according to a recipe.

Reinforced Concrete structures in which iron bars, wire, or rope have been placed in order to increase the structure's tensile strength is called reinforced.

Risk Insurance industry term for a building.

Ropewalk A building for sheltering rope spinning; before the invention of machines that could wind rope as it was spun, rope had to be walked out as it was spun. Consequently, these buildings usually are very long.

Side construction Hollow tile floor arches in which the cavity of the block is parallel with the beam.

Skewback The structural units at the end of an arch, with sloping side -- in the direction of the arch -- in order to start the springing of the arch.

Soffit The underside of a structural element, for example, the curved surface underneath an arch or the bottom surface of the lower flange of an I beam.

Terra cotta Clay.

Tile Clay products, with the exception of bricks. Terra cotta and tile are synonymous.

Vault An arched ceiling or roof made of stone or brick.

Voussoir Wedge shaped blocks, with sides slanted toward a central key block, which form an arch.

Web A vertical part of a beam or hollow tile.

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